P. G. Tsarfis

Nature and Health

Mir Publishers Moscow

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His studies employ new aspects of the immune, radio-immune, morphologic, cytophotometric, histoenzymochemical and neurohumoral evaluations of the effects of nature on man. He has created new concepts in this large medicosocial field; he is the author of over 200 research publications on this problem, 20 of which are monographs.

In topical research, he has been the adviser for 35 candidate and doctoral theses.

Prof. Tsarfis is World War II veteran. He is Head of the Clinical Department of the Institute of Physiotherapy and Spa Treatment, Vice-Chairman of the Scientific-Resort Commission of the Central Resort Management Council of USSR Trade Unions, Chairman of the Scientific-Resort Commission of the Moscow Trade Union Council, Member of the Scientific Board at the Institute of Physiotherapy and Spa Treatment. He maintains close contacts with resort physicians and scientists of different countries.

The book is about the natural factors existing in the world, such as climate, mineral waters, and therapeutic muds and peats. Their physicochemical characteristics are described as well as their healing effect in functional, inflammatory, and dystrophic diseases of the cardiovascular system, the organs of digestion, and movement. The book discusses the various methods used in applying physical factors for treatment and rehabilitation. It also throws light on the relationships between physician and patient, and councils the reader on how to become healthy.

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ИЗДАТЕЛЬСТВО · МИР ·

П. Г. Царфис

ПРИРОДА
И ЗДОРОВЬЕ ЧЕЛОВЕКА

Издательство «Высшая школа»
Москва

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Nature and Health

Treatment and Rehabilitation by Natural Factors

Translated
from the Russian
by A. Aksenov and N. Lyubimov

Mir Publishers Moscow

First published 1985
Substantially revised from the 1980 Russian edition

На английском языке

Contents

Preface 7

Introduction 11

From the Author 15

Chapter 1. Modern Concepts of Disease and Principles of Applying Physical Factors for Therapeutic, Prophylactic, and Rehabilitative Purposes 17

Chapter 2. Brief Characteristics of Natural Medicinal Resources of the World 27

Chapter 3. The Man-Nature Relationship 53

Chapter 4. Connection Between Systems Controlling Vital Activity and Systems Supplying the Organism with Energy and Formative Materials 71

Chapter 5. The Essence of Therapeutic Effect of Physical Factors 84

Chapter 6. The Use of Physical Factors in the Combined Treatment of Ischaemic Heart Disease 118

6.1. Myocardial Infarction: Treatment and Rehabilitation 118
6.2. Chronic Ischaemic Heart Disease: Treatment and Rehabilitation 124

Chapter 7. Physical Therapy of Patients with Hypertension 146

Chapter 8. Physical Factors in Therapy of Patients with Arterial Hypotension 167

Chapter 9. Healing Effect of Physical Factors on Obliterating Diseases of Great Arteries 173

Chapter 10. Physical Factors in Therapy and Rehabilitation of Patients with Chronic Venous Insufficiency of the Lower Extremities 181

Chapter 11. The Effect of Natural and Transformed Physical Factors in Digestive Diseases 192

11.1. Ulcer of the Stomach and Duodenum 193
11.2. Gastritis: Combined Therapy 208

Chapter 12. Combined Therapy of Patients with Hepatic and Biliary Diseases 215

Chapter 13. Combined Therapy of Various Diseases of Joints 227

13.1. Utilization of Natural and Transformed Physical Factors in Therapy and Rehabilitation of Patients with Arthrosis Deformans 230
13.2. Physical Methods of Treatment and Rehabilitation of Patients with Rheumatoid Arthritis 251

Chapter 14. Osteochondropathy 329

14.1. Osteochondropathy of the Head of the Femur (Legg-Perthes-Calvé's Disease) 330
14.2. Osteochondropathy of the Tibial Tubercle (Osgood-Schlatter's Disease) 335
14.3. Osteochondropathy of the 2nd and 3rd Metatarsal Bones (Köhler's Disease) 337
14.4. Osteochondropathy of the Condyle of the Femur (König's Disease) 339
14.5. General Comments on Resort Treatment of Patients with Osteochondropathy 341

Chapter 15. Diagnostic and Balneotherapeutic Mistakes in Diseases of Joints 343

Chapter 16. Long-Term Results of Resort Therapy in Diseases of Joints 351

Chapter 17. The Physician-Patient Relationship 363

Bibliography 372

Subject Index 382

Preface

The problem of the widescale use of natural and artificially developed physical factors in treating various diseases consists of many complex problems that have not yet been completely solved. These problems are primarily concerned with the mechanism of therapeutic action of these physical factors, the methods of their differentiated application, the combination of physical and balneotherapeutic procedures in the combined treatment of patients, the administration of drugs by physical methods, as well as the adequate use of therapeutic physical training exercises, prescribed physical exertion and so on. This is why this book published by Professor P. G. Tsarfis, which focuses on the solution of these questions from the viewpoint of a clinician specializing in spa treatment, is of immense scientific and practical importance.

The first part of the work provides a detailed evaluation of the main types of mineral waters, therapeutic muds and peats, of various climates, an assessment of different physicotherapeutic factors, and an interpretation of the mechanism of their action. It reveals from contemporary viewpoints not only the essence of the healing effect of natural and transformed* physical factors, but also describes the methods of their combined application, since the results of their diverse combinations in functional, inflammatory and dystrophic diseases are most effective.

The book lays proper emphasis on the fact that the application of physiotherapeutic procedures, particularly in active forms of diseases, in combination with sulphide, radon, iodobromine baths and various types of mud-cures, hydrokinesitherapy, and terrain cures is most expedient. Such an all-round approach is of great medico-prophylactic significance, particularly in preventing exacerbations of disease, for achieving stability and a long-lasting healing effect. This, in turn, promotes the more successful use of physical factors for therapeutic and rehabilitative purposes.

The problem of health and disease is specially discussed to gain a better understanding of the therapeutic effect of physiotherapy. This

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* By transformed factors we mean natural factors adapted for treatment.—(*Ed.*)

will help the reader to get an insight into the pathogenetic fundamentals of the therapeutic action of natural and transformed factors encouraging the reader to use them rationally for prophylactic purposes.

The dynamics of the clinical course of functional, inflammatory and dystrophic diseases, as well as changes in the biochemical, immunological, cytophotometric, histoenzymochemical indices under the effect of certain courses of balneo- and physiotherapeutic procedures are shown to explain the essence of the action of physical therapy. In dealing with these questions the author voices an original point of view which makes it possible to comprehend why one and the same type of mineral water or one and the same type of current or electromagnetic field may be successfully applied in several dozens of different nosological forms of diseases at various stages and in different phases of their development.

Professor P. G. Tsarfis points out that on a level with the central nervous system, great importance in the formation of general biological patterns of the development of diseases is acquired by adaptive systems and by the organ-specific characteristics of tissues which are involved in a pathological process.

The clinical peculiarities in the development of pneumonia, arthritis, hepatitis and nephritis are different, but the auto-immune, microcirculatory, redox and metabolic processes occurring in these diseases develop practically the same way. At the same time dystrophic processes affecting these organs are distinguished by their peculiarities connected with the diminishing adaptive-trophic function of the sympathetic nervous system, first and foremost of its hormonal and sympathetic links, as well as with the increased activity of the lysosomal enzymes, the higher level of metabolites, the change in the cytophotometric, enzymochemical, histostructural and other indices.

This is why the author focusses his attention on the mechanism of the therapeutic action of physical factors of those neuroreflectory and neurohumoral shifts which develop under the influence of balneotherapeutic and physiotherapeutic factors bearing in mind that these shifts are formed in different ways in the given classes of diseases. In inflammatory diseases neuroreflectory processes are activized under the effect of balneotherapy, the immune system is activated (non-specific and specific reactivity changes), the permissive effect of steroid hormones develops to a small degree, microcirculation and trophics of cellular structures improve. Under the effect of physiotherapy the synthesis of steroid hormones intensifies, the dissociation of protein-steroid complexes increases and free hormones are released; the binding power of transcortin is reduced. This leads to the increase of steroid metabolism, the intensification of the immunodepressant effect, a lesser permeability of tissue structures, and

the reduction of the exudative and proliferative components of inflammation.

Under the influence of a wide variety of natural physiotherapeutic factors, cellular metabolism and the physicochemical intracellular and molecular processes change more intensively than under the effect of balneotherapeutic factors; this is why, in active forms of the disease, particularly if it is of an inflammatory nature, physiotherapy is recommended, since it exerts a more pronounced therapeutic effect than balneotherapy. In some patients balneotherapy aggravates the process and calls for the inclusion of drugs or physiotherapy in the therapeutic complex.

Changes in the functions of endocrine glands under the influence of various balneo- and physiotherapeutic procedures in these diseases occur in different ways and are of general biological significance. In these processes (with due account for the physicochemical structure of the factor and the intensity of its application) the author perceives the specific characteristics of the healing effect of physiotherapy.

The propositions outlined in the book acquire practical importance for the rational organization of various medical balneo- and physiotherapeutic complexes and for increasing the efficacy of therapeutic and rehabilitative measures. The methodological principles which should be adhered to in elaborating the procedures mentioned are correctly formulated. In cases when the disease is in its active phase, the immunological reactivity is considerably disturbed, and also when the functions of the adaptive systems are considerably affected and the functional condition of the organism is unstable, physical factors must be used for therapeutic purposes. In such instances the method of their application should be mitigated and the dosage of physiotherapeutic factors brought down to a minimum; otherwise a disregulation of the neuroreflectory and neurohumoral processes may occur and an aggravation of the disease might ensue. On the contrary, if the activity of the disease abates, the function of adaptive systems is rehabilitated, and the functional condition of the organism is stabilized, physio- and balneotherapeutic factors may be used in rehabilitative treatment. In such cases the method of the abovementioned physical factors must become more intensive to eliminate hypokinesia, stimulate the adaptive-trophic function of the sympathetic nervous system, and improve the exercising of the myocardium and skeletal muscles as well as the regulation and restoration of the disturbed functions of the organism.

Thus, the facts described in this book shed new light on the mechanism of the therapeutic action of physiotherapy in most widespread diseases. They discover new important approaches for the wide use of physiotherapeutic and balneotherapeutic factors at spas and in everyday life. These facts also show how it is possible to use these

factors purposefully in medical prophylaxis and health rehabilitation.

In conclusion, I wish to note with great satisfaction that the book arouses great interest of the reader because it explains clinically the basic principles of the rational application of physiotherapy in hospitals and polyclinics, as well as at sanatoria and spas. It points out the advantages of the combined use of physio- and balneotherapeutic factors over the independent application of each factor separately.

I sincerely hope this book will prove useful not only for specialists of health-resort treatment and physiotherapists, but for a wide range of clinicians engaged in everyday work aimed at the prophylaxis of diseases, the treatment of patients, and the selection of patients to be sent for treatment to health resorts in different countries of the world.

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Introduction

The widescale use of natural physical factors for building up human health is a medico-biological and social task of profound importance. Its successful accomplishment requires that physicians be equipped with the necessary knowledge of the physical and chemical characteristics of different types of mineral waters, therapeutic muds and climates. Doctors must also possess a knowledge of the theoretical concepts of their therapeutic action on the organism. For the effective application of natural and transformed physical factors, however, it is vitally important for the physician to know the modern pathogenetic fundamentals of the main diseases of functional, inflammatory and dystrophic nature, as well as to be able to use various methods utilizing these factors for prophylactic, remedial and rehabilitative purposes.

Clinical experience has proven that a positive therapeutic effect is achieved, particularly in inflammatory and dystrophic diseases, under the influence of various combinations of physical therapy, rather than by this or that element applied separately.

Physical therapy includes natural healing factors (climate, mineral waters and medicinal muds) and transformed physical factors (galvanic current, electrical and magnetic fields, pulse currents of various frequencies, artificial spectrum of solar radiation, monochromatic coherent radiation (laser rays), mechanical oscillations (ultrasonics), aeroionization, etc. It is obvious that natural factors constitute the basis of spa therapy, while transformed factors comprise the foundation of physiotherapy. A substantial role in developing the complex of physiotherapy is played by a balanced diet, prescribed physical activity, mechanotherapy with the help of various apparatuses, sea bathing, bathing in rivers and swimming pools (thalaso- and hydrokinesitherapy), massage, etc.

The most effective combination of medicinal drugs with methods

of physiotherapy, particularly in active forms of the disease, calls for the use of spa therapy on a wider scale, and ensures a greater curative and rehabilitative effect. Moreover, the introduction of drugs by means of galvanic current (electrophoresis), ultrasonics (phonophoresis) and sinusoidally modulated currents (SMC-phoresis) will help considerably reduce the doses of drugs administered and enhance their remedial effect. This is particularly important for those patients who are given drugs over a considerable length of time.

It is necessary to note that patients suffering from collagenous and other inflammatory diseases who have been given steroid hormones and cytostatics over a considerable length of time become addicted to these drugs and cannot live without them. This makes some patients dependent on the given drug, while in others side-effects may develop to the point of steroid osteopathies, ulcers in the stomach and intestines, causing stomach and intestinal haemorrhages: if the steroid hormones are discontinued, withdrawal syndrome may arise.

All this makes it vitally essential to acquaint physicians with various aspects of physiotherapy for its wider use in subacute and recurrent forms of diseases, as well as after the performance of surgical operations both at health resorts and in ordinary conditions.

In view of this the book provides a brief description of the natural resources in the main health-resort areas, their location in various territories, the reserves of the principal types of mineral waters, healing muds and peats. Physicians must have this information to make a proper selection of a definite spa or local sanatorium where it would be most expedient to send patients with different clinical forms and phases of various diseases.

To better comprehend the profound complex changes which occur in the patient's organism while the physical factors are used, the book gives contemporary interpretations of health and disease, examines the new pathogenetic fundamentals of widespread diseases, describes the means of the physiological defense of the organism against disease, and reveals the essence of the therapeutic effect of natural and transformed physical factors, disclosing the negative influence of such factors when they are incorrectly applied.

The book gives an analysis of the author's concepts on the specific and non-specific effects of radon, carbon dioxide, sulphide and

other mineral waters, healing muds, and physiotherapeutic factors applied for this or that disease. Different methods are founded on the basis of such conceptions for applying a variety of physical factors (depending on the clinical form and stage of the given disease) for prophylactic, remedial and rehabilitative purposes.

It is also necessary to describe the aetiology, pathogenesis, clinical picture and diagnosis of the most important illnesses (ischaemic heart disease, hypertension and hypotension, diseases of the digestive organs, of the peripheral vessels of the extremities, joints and the spine), to reveal the essence of the action of physical factors in each of these maladies and suggest definite measures in applying physiotherapy.

These data are presented from the viewpoint of the clinician, a specialist in physiotherapy, because the general clinical aspects of the above-mentioned diseases are obviously insufficient for understanding the essence of the effect of natural and transformed physical factors. This is why each nosological form of the disease is accompanied by a discussion of the pathogenetic mechanisms forming the basis for the regulation and restoration of the disturbed functions under the influence of various elements of comprehensive physiotherapy which lead to practical recovery. The author shows the principal differences in the effect of natural and transformed factors, the significance of the segmentary-reflexive principle in applying these factors, the role of the intensity with which each physical factor acts when separately applied, particularly in combined therapy.

To understand how these factors work it is necessary to reveal the essence of those transformations in the organism which take place in inflammatory and dystrophic diseases under the influence of mineral waters and fangoes, as well as of various physiotherapeutic factors for elaborating the principles of physiotherapy in treating these diseases. It is necessary to establish (when using specially directed methods of applying physiotherapeutic factors) their overall effect on the functions of the adaptive systems and the local effect (on the pathological process); to determine the differences of these effects, to trace the dynamics of the pathogenetic fundamentals of many diseases, as well as to reveal the importance of the local action of the factor on the change of the pathological process itself. Moreover, it is necessary to disclose the mechanisms of the effect

produced by mineral waters on neuro-reflex processes, to trace the functional changes of various adaptive systems and bring out the synergism or antagonism that develops among them. This data is essential in planning combined physiotherapy which will account for the nature of the disease, the severity of its course, the activity of the inflammatory and stage of the dystrophic processes.

We proceed from the fact that the diagnostics and treatment of diseases of the joints and spine, particularly with the application of physical factors, are least of all described in the literature. A great part of this book is devoted to a discussion of the pathogenetic and clinical fundamentals of precisely these diseases. The book cites new factual material obtained from the study of biochemical, morphological, cytophotometric, histoenzymochemical and other changes in different tissues occurring in the development of various clinical forms and stages of these diseases. At the same time the work describes the clinicobiochemical, cytophotometric and histoenzymochemical dynamics as well as the complex of changes in immunological and hormonal indices under the influence of various therapeutical factors.

In other words, this book illuminates the role of physical factors (natural and transformed) in the prophylaxis, treatment and rehabilitation of patients, as well as in building up their health.

From the Author

Very different opinions exist to this day about the essence of the treatment and rehabilitation of patients suffering from the diseases known to man. Some authors equate treatment and rehabilitation, presuming that rehabilitation should be considered a continuation of treatment and that there is no difference in the methods using physical factors in one or the other. But the methodological fundamentals of the effect of various methods are quite different. In cases when the pathological process is in the active phase, the natural and transformed factors should be applied for treatment using methods of mild intensity. But when the morbid process wanes and it becomes necessary to restore the functions which had been disturbed by the disease, these factors should be applied using more intensive methods to achieve rehabilitation. This basic premise runs throughout the book, wherever the matter concerns the treatment and rehabilitation of patients suffering from different diseases.

Since this book is intended for specialists of many countries of the world, the physicochemical characteristics of natural remedial factors are presented from new theoretical positions which disclose the characteristics of the basic types of mineral waters, therapeutic muds and climates, no matter where these factors may be located.

For a clear understanding of the essence of the therapeutic and rehabilitative action of natural and transformed physical factors the book offers contemporary conceptions of health, disease and the mechanisms of action of these factors on the organism in different diseases.

To disclose the contemporary views on the pathogenesis and changes in the course of diseases under the influence of physiotherapy, the author has revised the main chapters of the book with the addition of the data obtained in recent years. For the most part, these are morphological, cytophotometrical, histoenzymochemical and immunological data which help to understand in a new light the essence of contemporary diseases and the effect on them of treatment and rehabilitation. This new information will help the physician to comprehend the nature of inflammatory and dystrophic processes and correctly prescribe mineral waters for external and internal use, therapeutic muds according to methods of different intensity

and climatotherapeutic procedures in the required doses. In moderate and pronounced activity of the inflammatory process the physician may include in the treatment various physiotherapeutic factors, first and foremost, high- and superhigh-frequency electromagnetic waves, short- and long-wave ultraviolet radiation, ultrasonics or sinusoidal modulated currents, and use them for administering drugs.

This book will encourage the more extensive use of natural and transformed physical factors for the treatment and rehabilitation of people in different countries of the world.

Chapter 1. Modern Concepts of Disease and Principles of Applying Physical Factors for Therapeutic, Prophylactic and Rehabilitative Purposes

It would be extremely difficult to give an exhaustive, all-embracing definition of such concepts as health and disease. There are numerous definitions in the medical literature, which only shows how difficult it is to uncover the essence of health and disease, to solve the endless problems interconnecting these two conditions. According to the World Health Organization, health is a condition of complete physical, spiritual and social well-being, and not merely the absence of diseases and physical defects. Besides this, health may be defined as the state of an organism in which all its functions and manifestations of vital activity are in harmonious and dynamic interaction with the environment. Nevertheless, health has been formulated in theoretical works and in medical practice in average statistical indices; in other words, a normal condition is determined on the basis of a number of constants established by anthropometric, clinical, physiological, biochemical and other research. These data may vary within wide limits depending on a person's sex, age, on constitutional, social, climatic and other conditions. In the process of perfecting medical knowledge the concept of the 'norm' becomes more precise. It has been established, for instance, that several functional indices of the organism change depending on the time of a day, the season of the year and so on. These data form the basis of a special branch of medical science, namely, biorhythmology.

Although the state of sound health excludes the existence of any kind of pronounced morbid changes, both the conditions of health and disease may be connected by a number of transitional stages. These stages may be certain subclinical forms of diseases, latent periods of sickness, and so on. Under the influence of unfavourable conditions of the environment the morbid process may manifest itself. The decisive factor in such a case is the overstrain and collapse of the protective adaptive mechanisms of the organism. The initial asymptomatic stage of the development of pathological changes, which sharply increase the sensitivity of the body to certain unfavourable influences of the environment, is termed the 'predisease'.

S.P. Botkin, one of the founders of Russian clinical medicine,

made a very valuable contribution to the development of the theoretical conceptions of disease and its pathogenesis. He was of the opinion that the core of a disease is formed by the reaction of the organism to detrimental influences of the environment, and that this reaction included both a combination of changes that result from the body's attempt to adapt to such influences, and compensatory changes of the disturbed functions.

One can see how hard it is to draw a clear-cut line between the states of health and disease, norm and pathology. It is impossible to define a disease without defining the norm, even though it would be incorrect to regard a disease merely as a deviation from the norm. If we consider the norm to be the preservation of all the vital functions in their totality, mainly the ability to work, it may be stated that the most general symptom of a disease is a decrease in the level of vital functions, a reduction of the vital activity of a person or its limitation, i.e. a disturbance of the social activity and of the capacity for labour. From this viewpoint one can clearly understand why Karl Marx spoke of the disease as life restrained in its freedom.

Ivan Pavlov's theory of corticovisceral pathology was a fundamental contribution to the study of disease. He emphasized that disease develops as a result of disorders in the relationship between the internal and external media of the organism. This balance is regulated, or rather 'organized', by the cerebral cortex. The flaw in this theory consists in the underestimation of the role of subcortical formations and the hypothalamus, and of the importance of the connection between the nervous and endocrine systems. Furthermore, the role of the cerebral cortex in regulating the vegetative functions of the organism was overestimated.

The functional activity of the so-called adaptive systems (the physiological systems helping the organism to adapt to the environment) is essential for preserving the equilibrium between the organism and its environment. These adaptive systems are: the hypothalamo-hypophyseal-adrenal complex, the hypophyso-thyroid complex, the hypophyso-ovarian complex, the sympatho-adrenal complex. the immunity system. These systems determine the condition of neurohumoral and endocrine regulation, the character of metabolic processes, the level of the organism's resistance to unfavourable environmental conditions.

If it is difficult to detect signs of imbalance at the beginning of the disease, under the influence of unfavourable conditions the pathological process soon becomes manifest. It is common knowledge that psycho-emotional stress in patients suffering from hypertensive disease may induce a hypertensive crisis; physical tension and negative emotions in patients suffering from angina pectoris cause retrosternal pain, an inadequate diet for patients with ulcers may cause an aggravation of the disease, and so on.

In various diseases many different adaptive and compensatory functional changes have been observed in organs and systems which become involved to protect the organism. As a result of the decompensation of protective mechanisms, vital organs and systems are often severely affected. The course of adaptive and compensatory processes depends on the degree to which the systems of regulation (central nervous system and adaptive systems) have been disturbed, as well as on the functional condition of the respiratory and digestive systems, the locomotor system, and the blood system. The exercising of these system, the increase of the resistance of the organism by hardening, healthy everyday life and a correct organization of labour are of profound importance in building up health and preventing disease. If this or that disease develops, however, the physician must have a clear conception of its pathogenesis so as to make the most effective use of all remedial measures aimed at eliminating or weakening the mechanisms of the disease and halting its progress.

Atherosclerosis, for instance, is a general disease of the organism caused by disorders of nervous regulation which lead to a shift in lipid and lipid-protein metabolism, which affects the arterial walls, including coronary and cerebral arteries, and the entire arterial bed. As a result of the affection of capillaries which supply the vascular wall, the trophics of the arteries are impaired, damaging the cells which line the inner surface of the vascular wall, thus forming defects in it and creating atherosclerotic plaques hampering the flow of blood. This is particularly unfavourable when the process develops in the coronary and cerebral vessels, the vessels of the distal parts of the extremities, and so forth. In atherosclerosis, disorders occur in the hypophyseal-adrenal, coagulation and anticoagulation blood systems which impair the process of blood supply even more. With time these disorders may lead to the development of angina pectoris, myocardial infarction or to gangrene of the distal part of the extremity. Each of these forms of the disease calls for specific medical tactics in applying therapeutic methods.

The combined treatment of atherosclerosis is pathogenetic in character, because its principal methods, drug therapy and treatment using physical factors, are aimed at restoring and regulating metabolic processes, blood circulation processes, improving the permeability of the vascular walls, the functions of the coagulation and anticoagulation blood systems.

Another widespread disease, infectious non-specific (rheumatoid) polyarthritis, is characterized by the affection of connective tissue, and mainly that of the osteoarticular apparatus. The non-specific infection which lurks in the tonsils, carious teeth, etc., acts as a trigger mechanism in the development of the disease, whereas functional disorders in the hypothalamo-hypophyseal-adrenal, hypophysothyroid, sympatho-adrenal and immunity systems determine the char-

acter and severity of development of the abnormal process in the joints and its tendency to progress. The combined pathogenetic treatment of this disease, in which drug therapy is to a great extent applied on a level with physical methods, aims at improving metabolism and trophics in the articular apparatus, normalizing the regulation of immune processes and so on.

In treating such widespread diseases as atherosclerosis of the coronary, cerebral and peripheral arteries of the extremities, the hypertensive disease, angina pectoris, myocardial infarction as well as collagenoses (rheumatoid arthritis, rheumatism, systemic lupus erythematosus and others) antibiotics, hormonal preparations and other drugs are widely used. The widescale inadequate and uncontrolled application of such drugs, and self-treatment may give rise to new diseases and adversely influence the organism, changing its reactivity and causing various complications of the main disease. It is an established fact that the longtime uncontrolled use of steroid hormones often results in ulcers of the stomach and intestines, in haemorrhages; changes in the bones may occur. Improperly prescribed antibiotics may lead to the appearance of candidiasis and allergy. Cytostatic preparations given in severe collagenoses may simultaneously affect the liver, kidneys, heart and other organs.

With time the patient's organism becomes used to the drugs and their effect is blunted; in such an event the patient resorts to larger doses which may result in complications. To avoid them, one must use drugs as they are prescribed and patients must be warned of the detrimental consequences of self-treatment. The physician must carefully watch over the changes occurring in the organism under the effect of drugs and take timely measures to prevent unfavourable reactions and reduce side-effects.

Some diseases, not only in their early stages, but over a chronic course with various degrees of disease activity may be effectively treated with physiotherapy in combination with drug therapy and other forms of treatment.

Under the term physiotherapy we mean the use of natural and transformed physical factors. It includes spa therapy and physiotherapy proper. The former comprises the use of mineral waters (balneotherapy), medicinal muds (pelotherapy), climatic factors (climatotherapy), as well as prescribed motor activity (physical training exercises, mechanotherapy, and so on), hydrokinesitherapy. Physiotherapy stands mainly for therapeutic treatment with the use of apparatuses and instruments invented and manufactured by man: phototherapy, electrotherapy, decimeter-wave therapy, inductothermia, ultrasonics therapy, and others. Physiotherapy used as an independent method of treatment or in combination with drug therapy may be not only of therapeutic, but of rehabilitative significance. Experience gained in treating patients at local specialized sanatoria

and health resorts shows that effectively designed combined therapy (a prescription appropriate to the form and course of the disease of various combinations of mineral baths, mud therapy, climatotherapeutic factors, hydrokinesitherapy, dosaged physical exertion, physiotherapy, massage) is very effective.

The physiology resulting from the therapeutic effect of natural physical factors in general and of climatotherapy in particular occurs because in the process of evolution the human organism had constantly been under the influence of climatic processes (as opposed to the effect of drugs, for example). In the process of the evolutionary development of man, such mechanisms of adaptation to climatic influences were formed as the system of the body's thermoregulation. Unlike drugs, natural therapeutic factors (when properly applied) produce no side-effects and do not give rise to new diseases.

The long years of studying the effect of various natural and transformed physical factors (balneological, climatic, physiotherapeutic, and hydrokinesitherapy) and their combinations in treating different diseases, and the increased efficacy of combined treatment made it possible to expand the range of indices for sanatoria-spa treatment and the more effective use of the possibilities of physical factors for curative, preventive and rehabilitative purposes. Scientific research and advanced practice in treating patients at local sanatoria and at health resorts revealed that physical methods of treatment may be applied not only in the early and chronic stages of disease, as it was presumed earlier, but also in the stage of functional disorders, in the period preceding the disease, soon after an acute disease has been suffered, during the subacute course of the disease or immediately after the recurrence of a chronic disease which tends to progress. This prevents further development of maladies, reduces the time of temporary incapacity and promotes the rehabilitation of the patient. To avoid exacerbations in the treatment with physical factors and to increase its efficacy special importance should be attached to a detailed examination of the patient for establishing the stage, activity and acuity of the process, for detecting concomitant diseases, the presence of foci of local infection (in the tonsils, teeth, accessory sinuses of the nose, etc.) and for eliminating these foci.

In combined treatment of patients who have suffered acute ischaemic heart disease, myocardial infarction and other diseases, physical factors are usually applied as part of continued treatment in a succession of stages: in-patient and out-patient clinic or polyclinic, local sanatorium, health resort and the polyclinic again.

At the first and second stages of treatment (in-patient clinic and local specialized sanatorium) therapeutic physical factors (both natural and transformed) are applied sparingly (i.e. with limited motor activity, terrain cure, aerotherapy, local mineral baths, electro- and heliotherapy procedures, etc.) under scrupulous control of

the general condition of the patient and the clinical manifestations of the disease. At the given stage and later (if the patient shows no clinical signs of the intensification of the process, or of pronounced haemodynamic, secretory and trophic disorders), the application of therapeutic physical factors is intensified and expanded by including additional remedial factors: prescribing mineral water per os, common mineral water and air baths, etc. In the absence of contraindications for spa treatment of patients, these factors may be applied at health resorts.

The correct order of individual treatments in the combined treatment of patients, the differentiated application of physical factors and their rational combinations become very important in treating patients suffering from the most common diseases. For example, patients with active forms of rheumatism after suffering a rheumatic attack involving the myocardium and who had received antibiotics and steroid hormone preparations during the early period of the pathological process may, after eight to ten weeks of a favourable course of primary rheumocarditis and after two to four months of recurrent rheumocarditis, be transferred from a local in-patient hospital to a local rheumatological sanatorium for further treatment. Abrupt discontinuation of hormonal agents may be accompanied in such patients by the so-called withdrawal syndrome which is characterized by a complex of hypocorticoid symptoms, as well as by a recurrence of the main disease: palpitation, fever, pain in the joints, loss of appetite, etc. To prevent or mitigate this syndrome, it is recommended along with more extensive regimen of increased activity to begin a course of treatment as early as at the in-patient hospital with high or superhigh-frequency magnetic oscillations, and to reduce the dose of steroid hormone agents, observing a daily routine of administration of these agents while gradually discontinuing them. Later, when the patients are already in the local sanatorium, combined therapy should include a special diet, vitamins (particularly of groups C and B), physical training exercises and a special regimen of greater activity. Of substantial significance, particularly in focal infection, would be prescribed ultraviolet radiation. Under the influence of this combination of enumerated procedures, the patients' adrenals begin functioning, as a rule, the synthesis of hormones intensifies as well as the splitting of the protein-steroid complex with the subsequent release of endogenous steroids.

These methods of treatment enhance the function of the sympathoadrenal system, intensify trophic and suppress inflammatory processes. When the combined treatment is efficacious such patients may be cured without drugs. It is only in rare cases, such as relapsing rheumocarditis, that treatment has to be combined with the administration of antirheumatic agents. Nevertheless, physicians should try to use minimal doses of the drugs. The derivatives of the pyrazo-

lone series and preparations of steroid hormones should be prescribed in smaller doses than those which patients usually receive at in-patient clinics.

In complete formed heart disease, during remission of the rheumatic process, in myocarditic cardiosclerosis and in the absence of contraindications, patients may be directed after treatment at an in-patient clinic and a local sanatorium to climatic and balneological spas. The application of climatotherapeutic procedures in combination with carbon-dioxide and radon baths combined with physical training exercises produces a positive healing effect. It is achieved by saturating the organism with oxygen, intensifying the metabolism and the functions of the cardiovascular system, and improving the contractile activity of the myocardium and intracardiac haemodynamics. All this promotes the rehabilitation of the disturbed functions of the organism in the diseases named.

Physiotherapy may be prescribed in the subacute period of such severe diseases as angina pectoris, myocardial infarction, hypertensive disease and many others when patients receive final treatment at local sanatoria.

Well-thought out advice to patients for treatment at health resorts may contribute favourably to the treatment of the above-mentioned and many other diseases. If the peculiarities of the course of the disease are not properly taken into account, however, treatment with physical factors, particularly under spa conditions, may lead to dire results. It is particularly hazardous to send patients suffering from atherosclerosis, stenocardia, or hypertensive disease in the phase of a so-called 'unstable' course to health resorts, the climatic conditions and the atmospheric pressure of which differ substantially from those of the areas of patients' permanent residence.

It is extremely important for the physician specializing in physiotherapy, particularly in spa therapy, to conduct a very careful examination of the patient and correctly determine the character, form and course of his disease. The examination should be conducted, despite the patient having been sent with a 'ready' diagnosis, for the appropriate prescription of physical factors, thus avoiding errors and exacerbations which might occur during spa treatment due to an insufficiently thorough examination of the patient. It is only when the physician has a thorough understanding of the changes taking place in the diseased organism and the functional systems which take part in this complicated process that he can correctly plan his treatment and cure, and choose the most effective method for mobilizing the defensive-adaptive mechanisms of the body for restoring and compensating the disturbed functions.

It is essential to plan the therapeutic complex in such a way as to prevent errors and aggravations resulting from physiotherapy. Poltoranov (1978) points out that mistakes in the diagnosis often give

rise to unfavourable consequences of spa treatment. Analysing the most frequently encountered errors made in defining various clinical forms of diseases of digestive organs, the author established that they had in essence been the main causes of exacerbations of the inflammatory and dystrophic processes in the stomach, the biliferous system, the pancreas, for the activation of a latent tubercular process in the digestive organs and for intensifying the growth of undiagnosed tumours of abdominal organs, etc. The same is true for a number of other diseases. This is why the very first obligation of the physician in prescribing any kind of natural factors consists in clinically defining the character of the disease and forming a concrete idea of the therapeutic effect of factors he intends to employ.

Physiotherapy plays a major role in combined therapy using physical factors. In exacerbation of the disease. for example, when it proves impossible to reduce the activation of the inflammatory process and drug therapy is necessary, the medicines are introduced in small doses by physiotherapeutic methods, their effect being simultaneously intensified. This is achieved by injecting the drugs into the organism by means of direct electric current, sinusoidal-modulated current, ultrasonics and other means (electro- and phonophoresis). These methods are preferable to per os administration, because in physiotherapy the drug is given in smaller doses, its effect is induced by electric current or ultrasonics and, besides, it is introduced directly into the internal medium of the organism.

At the beginning of the stage-by-stage treatment (polyclinic or in-patient hospital—local sanatorium—health resort) it is necessary to prescribe drug therapy for the patient, but in the subsequent stages, depending on the manifestation of the remedial effect caused by the action of appropriately selected physical factors and the improved condition of the patient, the doses of drugs in most cases have to be gradually reduced, and, if a stable positive result of spa treatment is achieved, completely discontinued.

Treatment with physical factors is of great importance in the primary and secondary prophylaxis of diseases. In functional disorders the methods of physiotherapy for the restoration and activation of several functional systems help to eliminate the initial (trigger) mechanisms of the disease. In chronic and active forms of the disease physiotherapeutic methods are conductive to the rehabilitation and compensation of disturbed functions, hamper the progress of the disease, reduce the number of exacerbations and relapses and thus serve as methods of secondary prophylaxis.

After a course of treatment at health resorts the patients are kept under dispensary surveillance. Continuity in treatment is not only of great remedial importance, but of prophylactic significance too. It is no less important for the rehabilitation of patients.

Rehabilitation in medicine consists of a system of measures aimed

at the fullest possible restoration of the health of patients and invalids to help them return to an active life and labour. In the USSR rehabilitation constitutes a comprehensive system of state, medical, psychological, socio-economic, production and other measures required by patients who have suffered myocardial infarction, a stroke, trauma or disease of the spine, an operation on the heart, diseases of the joints and so on. Rehabilitation is aimed at full, or at least, partial restoration or compensation of the disturbed or lost function, or at hampering the advance of the disease. The legal right to free medical aid, including rehabilitative aid, is guaranteed in the USSR by health care and labour legislation. The rehabilitative trend in public health care makes it possible for many patients to avoid disability and return to an active life.

Although it would be difficult to draw a definite line dividing the period of treatment of a patient and the beginning of medical rehabilitation, all measures of medical rehabilitation or restorative treatment are begun at the in-patient clinic immediately after the acute period is over. The patient stays at the department of restorative treatment before he is sent to a specialized local sanatorium or spa where he receives treatment with the entire complex of natural or transformed physical factors. This is the content of medical rehabilitation proper. All the other aspects of rehabilitation, such as production, psychological, pedagogical, socio-economic and everyday-life, are carried out along with medical rehabilitation and in close association with it. By the psychological aspect of rehabilitation we mean the influence which the physician exerts on the psyche of the patient by speaking with him, exercising psychotherapy aimed at developing the patient's confidence in the favourable outcome of his disease. The pedagogical and production aspects of rehabilitation include a complex of measures envisaging the patient's preparation for various new types of activity, training or retraining in accessible forms of labour, ensuring necessary individual technical devices for the patient's adaptation to new functional possibilities, the organization of special enterprises and production shops for patients and invalids with a shorter working day, easier working conditions, etc. Under everyday-life rehabilitation we have in mind providing patients and invalids with comfortable homes closer to their place of employment, whenever necessary, appointing living quarters on the ground floor and so on. Socio-economic rehabilitation includes payment to the patient or invalid of money grants compensating for temporary incapacity, the appointment of pensions, etc. This is the economic basis for the given form of rehabilitation. The medico-social essence of socio-economic rehabilitation consists in the fact that under the influence of natural and physiotherapeutic factors and motor activity, the defensive and compensatory mechanisms of the organism become in-

volved; these mechanisms form the basis of the regulation and restoration of disturbed functions and the return of patients to working activity. This reduces state expenditures for socio-economic purposes and helps to involve patients in socially useful labour.

The return of patients to active life greatly depends on the entire complex of rehabilitative measures, particularly the measures conducted at local sanatoria and spas and implemented with the use of physical factors.

To make rational use of the natural wealth of the world for remedial and rehabilitative purposes one must become acquainted with information pertaining to the spas and health resort regions of different countries which have various types of mineral waters, therapeutic muds and climatic factors.

Chapter 2. Brief Characteristics of Natural Medicinal Resources of the World

There are 4.5 billion people living and working on the continents of the Earth. The rates of morbidity and mortality are different in different countries of the world depending on natural, social and economic conditions, and different principles are adhered to in organizing the treatment of people and rehabilitation of their working capacity.

It has been common knowledge for a long time that nature provides man with many different benefits: the air and sunshine ensure life, the world of plants and animals yields energy and plastic materials, fresh water and mineral waters, and therapeutic muds promote physiological processes, cure people of diseases and restore man's working capacity.

There are ecological relationships, developed over the course of evolution, between man and nature which have as yet not been fully studied. The understanding of the complexity of these relations at different stages in the development of society presents possibilities for their adjustment to build up the health of the population.

From the medical and biological viewpoint, mineral waters and therapeutic muds acquire substantial recreational and prophylactic importance.

A closer acquaintance of physicians with the physicochemical properties of these natural remedial factors, their spread and healing effect in treating various diseases will contribute to an understanding of the importance of these natural factors in prophylaxis, treatment and rehabilitation, particularly now that the so-called diseases known to man have become so widespread throughout the world.

The study of these issues is not conducted with equal intensity in different countries. A considerable advance has been made in the last quarter of a century in the localization of mineral waters and therapeutic muds and their effective application in Austria, Bulgaria, Iceland, Hungary, Italy, Poland, USSR, Czechoslovakia and France. Moreover, during the same period an evaluation was made of thermal waters so that they may be used in the production of thermal energy and electric power.

The leading position of the Asian continent in exploring and studying thermal subterranean waters is held by such countries as Turkey and Japan. Major work in the comprehensive investigation of these waters is being conducted in India, Indonesia and Taiwan. A major role in the study of mineral and thermal waters belongs to Japan. In Japan new geophysical and geochemical methods are applied for determining the resources of subterranean waters, and extensive practical measures are employed in using hydromineral resources for transforming them into geothermal energy, in the production of which Japan is currently first in the world. For more than thirty years now this problem has been considered a task on par with affairs of national importance. Legal foundations have been worked out and established which forbid the use of hydromineral resources for purposes other than those officially designated.

On the African continent mineral waters are not studied everywhere. In some countries they have been explored in sufficient depth and are rationally used, while in other countries they are being poorly investigated. Good studies have been made of the mineral waters in Burundi, Kenya, Morocco, Tanzania, Uganda, the South African Republic and Ethiopia. The investigations conducted there are versatile; concrete characteristics of mineral waters, particularly of thermal waters, have been drawn up there, forecasts are studied for the thermal use of these waters, for balneological purposes, as well as a source of raw minerals. A definite trend has formed for the wider use of thermal waters in the North African countries, particularly in Egypt and Libya, but scientists pay considerably less attention to the study of subterranean mineral thermal waters in Angola, Zambia, Zaire, Congo, Cameroun and Senegal.

It is very unfortunate that in several African countries mineral waters and therapeutic muds are hardly used, particularly for balneological purposes. In Zaire, for instance, where there are sufficient reserves of subterranean waters and peloids, only a few types are used for therapeutic and rehabilitative purposes.

In recent years there has been a noticeable tendency to make a wider study and use of mineral waters in the United States. Special attention is focussed on discovering the hydrogeological conditions under which these waters originate, on establishing their physicochemical characteristics, defining the variety of microelements and gases which are of substantial importance for classifying the types of mineral waters, and using them for treatment and prophylaxis.

The countries of Central and South America have also begun extensive investigations of thermal mineral waters. Particular interest is shown in the production of geothermal energy and determining the physicochemical properties of subterranean waters and their classification. The ways and means for utilizing mineral waters for therapeutic purposes are being outlined.

Much interest is shown in the Soviet Union not only in the study of mineral waters and therapeutic muds from the hydrogeological and hydrothermal aspects, but in revealing the specific features of the genesis and reserves of these waters. Substantial significance is attached to the study of various types of therapeutic muds and mires, the setting up of sanitary protection zones, elaborating balneotechnical devices and widely utilizing natural factors for the treatment and rehabilitation of people suffering from various diseases.

To understand the complex structure of mineral waters and to develop effective measures for their utilization, however, it is necessary to conduct widescale research in the areas of hydrogeology and medicine.

Based on many years of research, Ivanov (1982) arrived at the conclusion that subterranean waters form primarily at the expense of natural waters of different origin, namely, atmospheric, sea, lake and mixed waters. The chemical composition of these waters depends on the complicated combination of several geological factors and geochemical processes: the chemical composition of the initial waters, the composition of water-absorbent rocks, first and foremost on the presence of water-soluble salts, on contemporary and paleohydrogeological conditions harbouring the possibility for the long-term preservation in rocks of salt components and ancient magmatic and thermometamorphic processes causing the generation and the accumulation of carbon dioxide (CO_2) in the waters, on contemporary volcanic phenomena leading to the absorption by water of high-temperature volcanic gases of complex composition. Moreover, the chemical composition of mineral waters is the result of neotectonic processes, which create deep tectonic fissures that are open to the rushing water, and the existence in the powerful thickness of sedimentary rocks under moderate temperatures and pressures, as well as biochemical processes of disintegration of organic substances, and, under high temperatures and pressures, various chemical and thermochemical processes of the interaction of rocks and mineralized waters. All these frequently interconnected processes lead to the accumulation in subterranean waters of different ion-salt and gaseous components, to the complex processes of the metamorphosis of the chemical composition of subterranean waters in the course of geological periods. Under the influence of these processes complex, but quite natural, ways are formed for the spread of different mineralized waters in the bowels of the Earth's crust. Under certain geological conditions quite definite types (in chemical composition and genesis) of mineral waters can form.

A considerable portion of subterranean mineralized waters are mineral waters, that is, such waters which may be effectively used for healing and prophylactic purposes.

There are different criteria in different countries for classifying

mineral waters. According to Soviet specialists, waters are mineral when they contain mineral (more rarely organic) components in increased concentrations and (or) gases possessing certain specific physical properties (radioactivity, an active reaction of the medium, etc.) due to which such waters exert a therapeutic effect on the human organism.

Frike (1970) pointed out that in FRG and Austria all the outlets and springs from which natural waters usable for medical purposes flow are regarded as mineral springs of curative waters. Carle (1975) recommended taking into account the balneotherapeutical effect of mineral water emphasizing that in this case mineral water could be termed 'medicinal water'. Just like other European scientists he considers all waters containing 1000 mg/kg or more of soluble substances to belong to mineral waters. Irrespective of this, in Carle's opinion, the waters may be called mineral if they contain therapeutically active components in the following amounts (mg/kg): titrated sulphur 1.0; carbon dioxide 250; iron 10; arsenic 0.7; iodine 1.0; radon 1.8 nanocurie/l.

In some other countries attempts are being made to segregate the concepts 'mineral water' and 'medicinal water', viewing the former in the wide sense of the term and the latter in its narrower balneotherapeutical meaning.

Shcherev (1975) considers mineral water to be subterranean water which in its substance and energy, or rather predominantly in energy (thermal, redox, nuclear radial) differs essentially and authentically from the local or regionally-climatic standard of ordinary (cold and fresh) waters.

In France, where there are many subterranean waters, specialists differentiate mineral waters by their therapeutic properties for external, and particularly for internal application. In Argentina, Belgium, Brazil, Spain, Italy, Cuba, United States, France and Switzerland the term 'mineral water' is associated with its therapeutic effect. It may be regarded as mineral water if it renders a pharmacotherapeutic effect. This may be caused by the presence or even the absence of some specific elements irrespective of their quantitative content.

Flerov and Marinov (1982) emphasize that in Czechoslovakia it is asserted that mineral waters must differ from ordinary subterranean waters either in their composition or temperature, due to which they exert a certain therapeutic effect on the patient. Mineral waters having therapeutic properties are called therapeutic mineral waters. Therapeutic waters are considered to be those which contain up to 2 g/l of carbon dioxide, 5 mg/l of lithium, 25 mg/l of bromine, 10 mg/l of iodine, 5-10 mg/l of H_2S; radioactivity is 36.2 nanocurie/l.

In Spain mineral water is considered to be such if its dry deposit equals no less than 0.2 g/l and also when it contains soluble

substances and gases in amounts permitting their use in industry. In such instances they are designated as mineral-industrial waters.

In the United States, Canada and some countries of Central and South America subterranean waters are considered to be mineral if they contain more than 1000 mg/l of soluble substances, or waters with less mineralization, but possessing specific chemical and gaseous composition which produce a therapeutic effect.

White (1969) held the view that in Australia thermal are those waters, the temperature of which is 5 °C higher than surrounding stratum waters. The mineral waters are warmed by convective circulation of heat or by anomalous thermal streams. All waters at depths of more than 300 m, claims the author, are either mineral or thermal.

The factor of temperature is of major importance in determining the healing qualities of mineral waters. In such European countries as GDR, Italy, Poland, Rumania, FRG and Switzerland, thermal are those waters the temperature of which reaches 20 °C, in Czechoslovakia up to 25 °C, and in Hungary up to 35 °C. In the rest of the European countries, just as in the United States, Canada, Japan and Turkey, thermal are considered to be those waters which upon their release register above annual average temperature for the given locality. In Egypt thermal waters register 35 °C at the outlet, in Vietnam and Thailand over 30 °C and in the Scandinavian countries at about 12 °C.

In India waters of any mineralization which differ from their background subterranean waters in their microcomponent gaseous composition or radioactivity are considered to be mineral waters. In Japan and Turkey mineral are those waters which contain an amount of microelements or soluble substances that is more than 1000 mg/kg.

Thus, there are such different approaches to the very definition of the concept 'mineral water' to say nothing of their special features. The approach is of major importance in defining the type and class of mineral water used for therapeutic purposes.

The definition of the type of mineral water is also arrived at by many different approaches in principle. Each of the many countries faced with this task has elaborated its own approaches. Carle (1975) conducted a widescale investigation of mineral waters in several European countries (Austria, Belgium, Hungary, GDR, Denmark, FRG, Switzerland) and came to the conclusion that most often subterranean waters can be divided into sodium chloride, calcium and magnesium, sodium hydrocarbonate, magnesium and calcium, or sodium sulphate, calcium, magnesium and ferrous waters. Each of these types has different gaseous components and microelements, as well as different temperatures. This is why Carle deemed it necessary to distinguish a few combined types of waters: iodosulphate

brine; sodium chlorosulphate carbon dioxide thermal water; iodobromine brine.

France has long been using the genetic classification of mineral waters with due account for the geotectonic structure of the region. This classification is based on the meteoric origin of subterranean waters which acquire a specific geochemical character because of their long-term existence in the bowels of the Earth. The absorption of carbon dioxide by mineral water is the result of magmatic processes occurring in the lower part of the Earth's crust.

In Spain and Poland the approach to classifying mineral waters into various types and groups was simplified. Spanish hydrogeologists chose two factors as the basis for their specification of mineral waters, namely, chemical composition and balneotherapeutic properties. They distinguish eleven types of waters including hydrocarbonate, chloride waters in which the content of sodium chloride is no less than 1 g/l; hydrogen sulphide waters, sulphate, ferrous, oligothermal waters mineralized less than 1 g/l; nitric, carbon dioxide, radioactive, iodine and arsenious waters. Unfortunately, this classification lacks quantitative indices by means of which it would have been possible to take their value into account when tackling balneotherapeutic tasks.

In Poland four types of mineral waters are distinguished by chemical composition: (1) carbon-dioxide mineral (brines) or weakly mineralized, containing 1 g/l and more of free carbon dioxide; (2) sulphide, mineral (brines) or weakly mineralized, containing free hydrogen sulphide or the sulphide ion HS; (3) brines (mineral waters) with an increased content of iodine, bromine, iron; (4) other mineral (brines) and weakly mineralized waters of ordinary chemical composition. In distinguishing these types of waters radioactivity is also taken into account.

In Rumanian waters Pascu (1974) distinguishes 12 types according to microelements and the characteristics of chemical and gaseous composition. In eight of these he distinguishes several subtypes or categories, the number of which is designated in brackets: oligomineral (7), carbon dioxide (23), ferrous (14), hydrocarbonate sodium potassium (12) and calcium magnesium (9), sodium chloride (17), iodobromine (7), hydrogen sulphide (2), sulphate (13), arsenious, radioactive, sulphide; a special type combining thermal waters. The classification of mineral waters in Hungary is built on a similar principle. Hungarian scientists distinguish 9 types: carbon dioxide, sodium hydrocarbonate (soda water), calcium magnesium hydrocarbonate, chloride, sulphate (bitter-salty), containing ferro-alumosulphides, hydrogen sulphide, iodobromine and radioactive waters.

Bulgarian scientists base their classification of mineral and thermal waters on geogenetic indices according to conditions of the distribution of waters in crystalline massifs and artesian basins. Sever-

al classes of water are distinguished by their chemical composition: acrotherms, hydrocarbonate, chloride, sulphate, nitrates of complex anion composition. According to mineralization, they distinguish (in g/l): acrotherms, up to 0.5; weakly mineralized waters 0.5-1.0; mineralized waters 1-3.0; medium-mineralized waters 3-7.0; strongly mineralized waters 7-15.0 and very strongly mineralized waters $>$ 15.

Shcherev (1975) reviewed the existing classifications of mineral and thermal waters and arrived at the conclusion that they fail to reflect the substantial, energetic and genetic varieties of subterranean waters. Proceeding from this, the author suggested his own scheme in which he views mineral waters as a specific medium which both destroys and creates minerals, is distinguished by its mobility and changeability, and which serves as an indicator of the processes taking place in the crust of the Earth. Shcherev makes his scientific classification of natural mineral waters on the basis of an abstract model of the entire system of mineral waters in conjugated genetically substantial, energetic and spatial-time axes. Subsystems of lithomorphic and exolithomorphic waters are distinguished by the origin of the solvent and the substances dissolved in it. Endogenous waters, the solvent of which is of juvenile (mantle-magmatic) origin, are not discussed by the author because of their extremely limited origin, and metamorphic waters are not examined due to the absence of strict objective criteria for their substantial and spatial segregation. Taxonomic units are distinguished in the system of exogenous waters; they include 2 subsystems, 4 groups, 19 classes and 65 types of mineral waters. This classification is too eclectic, of course, and its practical application is difficult.

Czechoslovakian specialists go by a classification of mineral waters which takes into account the nature of their structure, the degree of disclosure, the hydrodynamic zones and the category of discharge zone. It is suggested that the correlations among the designated indices be expressed in letter-digital symbols.

In India classifications of mineral waters have been worked out which take into consideration their chemical composition as compared to the well-known therapeutic waters of European spas (Vichy, Zheleznovodsk, Marianske Lazne, Pyatigorsk, Djurmuk, and others).

Kent (1969) distinguished the classification of mineral waters on the African continent according to the characteristics of their chemical composition. The classification consists of five classes of waters:

A, mineralized chloride-sulphate water with a general mineralization of more than 1 g/l, a chloride content of more than 27 per cent, of sulphates more than 5 per cent;

B, moderately salty water, mineralization usually more than 0.3 but less than 0.5 g/l, chloride content about 27 per cent, sulphates less than 3 per cent;

C, carbonate water of temporary hardness, mineralization less than 0.8 g/l, pH more than 7.6;

D, alkaline hydrocarbonate and sodium carbonate water with the content of these components of more than 15 per cent, mineralization less than 1 g/l;

E, water of general mineralization that is less than 0.2 g/l. The mineral waters may be further characterized by a certain content of microelements, namely, of Fe, Mn, Li, Sr, I, Br.

The mineral and thermal waters of Morocco are divided into medical, or therapeutic, and thermal waters based predominantly on their balneotherapeutic aspects. In the South American countries the classification of mineral waters is mainly based upon chemical components. In the United States and Canada there are several classifications which have been published by White (1969). Much importance is attached to the chemical composition of waters. Five classes are distinguished in the genetic classification: meteoric waters which had recently participated in the hydrogeological cycle; partly interred waters; partly metamorphosed waters; juvenile waters; partly volcanogenic or magmatic waters.

The official classification of mineral and thermal waters in Japan has been published in a law on hot springs. This classification emphasizes the importance of the chemical composition of mineral waters. In elaborating the classification of mineral waters, an important role has been allotted to the factor ot temperature in several countries (Bulgaria, Hungary, Italy, Switzerland, Japan, Canada, USA). According to White's data, the division between warm and hot waters in the USA and Canada is drawn at 32 °C. In the USSR the classification of mineral waters is based on consecutively elaborated principles for evaluating subterranean mineralized waters from the viewpoint of the hydrogeologist and balneotherapist.

The most acceptable classification of mineral waters has proved to be that of Ivanov and Nevrayev (1964). This extensive classification takes into account the basic hydrogeological and physicochemical features and the therapeutic importance of mineral waters. However, this classification makes no recommendations in regard to the medical application of waters. Possibly, this is because the aspect in question is most complex and difficult, a matter which warrants further discussion.

Ivanov (1982) worked in close contact with physicians for over 40 years. He took into consideration the principal components of mineral water, which determine its healing properties, primarily, the mineral and gaseous composition of subterranean waters, the anions and cations, specific components, organic substances, acidity and alkalinity, as well as different temperatures.

By chemical composition, physical properties and healing effect he distinguished eight balneotherapeutic groups among mineral waters:

I, without specific components and properties;
II, carbonate;
III, sulphide;
IV, ferrous, arsenious and 'polymetallic' with an increased content of several metals: Mn, Cu, Pb, Zn, Al, and others;
V, bromine, iodobromine and iodine;
VI, radon (radioactive);
VII, siliceous thermal;
VIII, weakly mineralized, with a high content of organic substances.

It should be noted that there are now 273 sites of mineral waters in the USSR. They are used for treating patients suffering from cardiovascular diseases, for whom carbonate waters are most helpful; such waters are currently found at 37 sites. There are 38 known locations of sulphide waters which are used for patients with diseases of the joints and spine, as well as for patients with diseases of the peripheral nervous system. Moreover, it is also useful to prescribe radon waters for such patients, which exist at 13 locations; iodobromine, bromine and iodine waters are found at 10 locations. Besides, there are waters without specific components or properties; siliceous, arsenious and ferrous waters are mined at 164 locations. They are successful in the treatment of many diseases in which various functional systems of the organism are disturbed.

Specific indications have been determined for sending patients with certain diseases to various spas of the world where there are waters conducive for curing this or that disease. Medical scientists have likewise defined the contraindications for sending patients to such spas and sanatoria.

It is necessary to note, however, that the physician must know which gases are contained in the types of waters mentioned, because gaseous components are of major importance in the healing qualities of mineral waters for different diseases.

As early as at the turn of the century Vernadsky (1912), who was not a physician, emphasized the importance of gases in subterranean waters.

'Major importance,' he wrote, 'should be attached to gaseous components in natural waters. There cannot be any natural water which would not be saturated by the gases of the Earth's crust in which it exists and where it was formed.' This conception, of course, is of genetic, hydrological significance in regard to subterranean waters, because the gaseous component provides a clue to the processes taking place in the Earth's crust and gives an idea of the mechanisms forming this or that type of water.

From the medical point of view it is important to know that there may be different combinations of gases in mineral water. The principal combinations are nitrogen (N_2), carbon dioxide (CO_2), meth-

ane (CH_4), radon (Rn), and hydrogen sulphide (H_2S). It should be borne in mind that, as a rule, oxygen (O_2), hydrogen (H_2), argon (Ar), helium (He) and certain other rare gases are contained in mineral waters in very small amounts and do not play a substantial role in determining the healing properties of mineral waters. The concentration of carbon dioxide or hydrogen sulphide, however, is of great significance. Thus, if carbon dioxide water (Narzan) contains less than 0.6 g/l of CO_2 the therapeutic effect of narcosis is extremely low, particularly in patients with ischaemia of the heart, angina pectoris in the phase of remission (when there is no attack for an extended period), arterial hypertension, and other diseases. In such cases the low effect is caused by the insufficient amount of carbon dioxide which in small doses fails to produce a vagotropic or hypotensive effect and cannot enhance the adaptive-trophic function of the sympathetic nervous system, improve the trophics of the myocardium, cannot reduce peripheral pressure, the cardiac output in the hypertensive disease, and so on.

It is also important to know the state in which this or that gas exists in the water. Gases may be in a dissolved or in a free state. In the former case these are dissolved gases, and in the latter spontaneous gases. The general gaseous composition of mineral waters is a compound of dissolved and spontaneous gases. Depending on this, there may be aerated and non-aerated mineral waters. It should be remembered that therapeutic waters may have simple or complex gaseous compositions. Simple waters contain one gas (nitrogen, methane, carbon dioxide), complex waters consist of several gases (nitrogen-methane, nitrogen-carbonate, hydrogen-sulphide-methane, nitrogen-radon, and so on), where each of the gases mentioned is contained in amounts of no less than 10 volume per cent. The gases possess dual significance; on the one hand, they exert a stimulating effect on exteroceptors, and on the other, upon entering the internal medium of the organism, they enhance the excitability of nerve centres and change their reactivity. Both are of substantial importance in the mechanism responsible for the waters' effect.

One must bear in mind that the name of the waters is determined in order of the increasing content of different components. When the content of nitrogen in the water is 25 volume per cent, methane 30 and carbon dioxide 45 volume per cent, the water is called nitrogen-methane-carbon-dioxide water. The physician, and even more so the hydrogeologist, must also know that all the water-soluble compounds existing in the bowels of the Earth are contained in dissolved form in subterranean mineral waters, although in very different quantities ranging from fractions of a milligram to hundreds of grams per litre of water. In this subterranean 'drugstore' the predominant ions determining the ion composition are Cl, SO_4, $HCO_3(CO_3)$ and the cation composition is made up of Na, Mg and Ca. Much rarer

are other ions present, such as Fe, Al in acidic, vitriolic waters of ore (sulphide) deposits, and Fe, Al, NH_4, SH in the fumarole therms of the regions of modern volcanism. These elements can affect the functioning of the adaptive systems, particularly the sympathico-adrenal, hypophyso-thyroid and hypophyseal-adrenal systems when the patient is being treated with acidic or alkaline mineral waters or with therapeutic muds.

The content of certain ions of no less than 20 equivalent per cent is accepted as criteria for differentiating mineral waters according to their ion composition. This is why only those ions which are contained in mineral water in a designated number determine the name of the water.

According to both ion and gaseous composition, mineral waters may be of simple ion composition if only one anion and one cation is contained in amounts of no less than 20 equivalent per cent. When there are two-three anions or cations (also in the same amounts) the mineral waters should be evaluated as waters of complex ion composition (e.g., chloride calcium-sodium, chloride-hydrocarbonate sodium, and others).

This evaluation is necessary so that physicians and hydrogeologists might speak the same language, so to say, to understand the structure of mineral water just like the composition of medicinal solutions.

An important role here belongs to the mineralization of mineral waters (M). This term stands for the sum total of all the substances dissolved in the water (in g/l).

In the All-Union Classification of Minerals in Subterranean Waters (1976) and in the Rules for the Development of Deposits of Mineral Waters in the USSR (1978) there are seven gradations of mineralization:

1. Waters of weak mineralization characterized by a content of less than 2 g of mineral salts per litre of water. These waters, however, may be considered therapeutic provided they contain specific elements in increased amounts. Without these elements their therapeutic effect is negligible. Moreover, such mineralization will most likely cause an exacerbation of the given disease.

2. Waters of low mineralization distinguished by a mineral content from 2 to 5 g/l. It should be borne in mind that a mineralization of 5 g/l is more often than not the top limit of two very widespread types of mineral water, namely: nitrogen sulphate waters of complex cation composition (Ca, Mg, Na) and carbon-dioxide hydrocarbonate magnesium-calcium waters, which have proven to possess substantial healing qualities for patients with a minimally pronounced inflammatory process or the process in the stage of remission. Their role increases in the treatment of patients suffering from dystrophic diseases, particularly for persons older than 60 when higher concen-

trations of salts in mineral water may aggravate the course of the disease.

3. Waters of medium mineralization containing 5 to 10 g/l of salts. They are most often represented by sulphate-chloride, chloride and hydrocarbonate-chloride waters of various cation and gaseous composition. These waters may be successfully used in baths for young patients suffering from combined inflammatory and dystrophic diseases.

The group of subterranean waters of low and medium mineralization include the overwhelming majority of therapeutic waters prescribed for internal use in functional, inflammatory and dystrophic diseases of the stomach, the biliferous system, intestines and pancreas. These waters may also be used for transduodenal and underwater intestinal irrigation, microenemas and other intestinal procedures.

4. Waters of high mineralization (10-35 g/l) are mainly chloride and hydrocarbonate-chloride sodium waters. They are used externally for baths and swimming pools in treating many dystrophic diseases of the locomotor system, in inflammatory-dystrophic diseases of the peripheral nervous system, particularly for young patients.

5. Brines, which constitute an extensive group of mineralized subterranean waters of chloride sodium and calcium sodium content. Their concentrations range from 35 to 150 g/l. Brines with a mineralization ranging from 35 to 50 g/l may be used for external application. In other variants brines must be diluted by fresh water, otherwise they cannot be used for medico-prophylactic purposes.

6. Strong brines (mineralization from 150 to 350 g/l) mainly of calcium-sodium composition. They are located mainly in the deep strata of some artesian basins and are genetically linked with massive salt-bearing deposits.

7. Very strong (ultrastrong) brines with a content of more than 350 g/l. Brines with mineralization of up to 600-650 g/l are of chloride, mainly of calcium-sodium, magnesium-calcium and even calcium or magnesium composition. All strong brines may be used for therapeutic purposes provided they are diluted by fresh or low-mineralized waters.

Specific components play a very important role in determining the therapeutic properties of mineral waters. They include substances present in mineral waters in small amounts which do not determine their basic chemical composition, although they are of substantial significance when these waters are used for therapeutic purposes, particularly if they are prescribed for internal use. Among the specific components are CO_2, H_2S $(+HS)_3$, Al, Br, I, Fe, H_2SiO_3 $(+H.O_3)$. There are no world standards for the content of these components in various mineral waters of different countries. Nevertheless, it should be noted that their quantity must be one or two orders higher than the ordinary background content in corresponding types of subterra-

nean waters. In mineral waters such values for active components possessing therapeutic importance are (expressed in mg/l): CO_2—500; H_2S (+HS)—10; Fe—20; As—0.7; Br—25; I—5; H_2SiO_3 (+$HSiO_3$)—50; and also Rn—5 nanocurie/l. Depending on the level of these elements mineral waters are designated respectively: carbon dioxide, sulphide, ferrous, arsenious, bromoiodine, radon, and others.

Depending on the temperature of mineral waters, one and the same amount of carbon dioxide anhydride may exist in water either only in dissolved or simultaneously in dissolved and spontaneous forms. The higher the temperature, the relatively greater quantities of carbon dioxide will exist in a spontaneous state. If at 30 °C the volume weight of carbon dioxide is 1.71, at 50 °C it will be 1.61 g/l. In distilled water the corresponding figures will be 1.257 and 0.761, respectively. This is why in highly thermal waters the assessment of CO_2 content should be made according to the sum total of dissolved and spontaneous CO_2.

Carbon dioxide waters are widely used for therapeutic treatment of cardiosclerosis, atherosclerosis of the coronary vessels, ischaemic heart disease, hypertensive and hypotensive diseases, neuroses with cardiovascular manifestations (the angioneurotic form of stenocardia, cardialgia, bradycardia) during baths, bathing in swimming pools and also prescribed for drinking. In bath treatment the content of carbon dioxide is from 1.4 to 2.5 g/l. For internal use the content is within 0.5-0.7 g/l. It should not be forgotten, however, while drinking Narzan, that it contains a certain amount of hydrocarbonate, which under the influence of hydrochloric acid in gastric juice turns into free carbon dioxide.

Carbonate waters used in balneotherapy are divided into three groups: weak carbonate waters with a 0.5 to 1.4 g/l concentration of carbon dioxide; of medium concentration from 1.4 to 2.5 g/l; and high carbon dioxide concentration of more than 2.5 g/l. It should be noted that in many pools of carbonate waters the content of CO_2 reaches 10 g/l and higher. The mineralization of these waters ranges from 1 to 15 g/l, in rare instances higher (25-35 g/l). In ion composition seven groups of carbonate waters are distinguished: hydrocarbonate, sulphate-hydrocarbonate, chloride-hydrocarbonate, etc. Most of the carbonate waters with a mineralization from 2 to 15 g/l are used for drinking and as medicinal waters.

For the first time in world practice the Soviet Union established a nationwide standard (GOST)* for bottled natural mineral water. According to this standard, they are divided into two groups: dinner table drinking water with a mineralization of 2-8 g/l and medicinal waters with a mineralization of 8-12 g/l. Drinking therapeutic waters

* GOST—State All-Union Standard.

also include those with a mineralization of less than 8 g/l provided they contain biologically active microelements (iron, arsenic, bromine, iodine, etc.) in amounts exceeding established norms.

Proceeding from the premise that treatment prescribing drinking mineral water requires that apart from mineralization the water must be of ion composition, all drinking mineral waters are differentiated according to the GOST standard by their anion and cation composition into 28 groups; in other words, they are more fractionalized than mineral waters for external application.

Waters containing increased amounts of specific biologically active microelements are listed in GOST as ferrous, arsenious, bromine, and iodine waters and distinguished as variants of certain groups of waters. Drinking waters are not classified according to their gaseous composition, because when they are bottled, all waters irrespective of their natural gas components are saturated with CO_2 (up to 0.4 per cent) and become highly gas-saturated carbonate waters. The saturation of bottled mineral water with carbon dioxide helps to preserve its physicochemical properties and prevents the appearance of a precipitate. Bottled mineral water is therapeutically effective when the physician prescribes it according to a certain method depending on the nature of the affection of the main digestive glands, disorders of metabolism and the condition of other organs and systems of the body.

Sulphide waters are widespread among subterranean mineral waters in different regions of the world. Hydrogeologists have shown quite convincingly that these sulphide waters are formed by the biochemical reduction of sulphates. The following conditions are essential for this process: the presence of gypsum-bearing ores and organic substances which ensure the vital activity of sulpha-reducing microorganisms; anaerobic conditions and the absence in ores of iron and other metals capable of binding sulphides out of mineralized waters.

Anisimov (1976) notes that in the deep strata of artesian basins, where the vital activity of sulphate-reducing microbes is impossible, sulphides will most likely be formed by the disintegration of sulpha-organic compounds. In sulphide waters the concentration of hydrogen sulphide is within the limits of tens, hundreds and even thousands of milligrams per litre of water.

Sulphide waters are successfully applied in treating many diseases of the joints and the spine, radiculites and neurites, ischaemic heart disease, hypertensive, skin and other diseases. It is important to become skilfully trained in the application of adequate methods of their use to achieve the desirable healing effect. There is an erroneous opinion to the effect that the higher the sulphide concentration in mineral water, the more pronounced its effect. Special investigation has proved that high concentrations of sulphides in water pene

trate the inner medium of the organism as strong oxidizers; sulphides become involved in cell metabolism, sharply intensifying redox processes and resulting in the exacerbation of any disease not only of an inflammatory, but also of a dystrophic nature. This is why the balneotherapeutist must know the gradient of sulphide waters to be able to use the most effective of them for attaining a healing effect. The lowest acceptable limit of this index permitting the water's classification as sulphide water is a concentration of $H_2S + HS$ 10 mg/l. Waters with such a concentration are designated as weak sulphide waters. Medium sulphide waters have a sulphide concentration of 50-100 mg/l, strong sulphide waters 100 to 250 mg/l, very strong sulphide waters 250-500 mg/l, and ultrastrong sulphide waters possess a sulphide concentration of 500 to 3000 mg/l. It would be, of course, hard to underestimate the medical significance of this differentiation. Spa practice and scientific research have shown that weak sulphide waters induce practically no reaction and it is considered that such a concentration reaches the low threshold of stimulation of nerve endings in the skin and determines the moment when the skin begins to redden. This sulphide concentration is very low and the therapeutic effect consequently weak. If, besides sulphides, there are mineral salts or carbon dioxide in the water, the therapeutic value increases. Medium sulphide waters are most effective for treatment. Strong sulphide waters should only be prescribed for patients with a limited number of inflammatory and dystrophic diseases; in these patients the cardiovascular and broncho-pulmonary systems must be functioning normally; complete absence of any hepatic or renal diseases is necessary. Very strong and ultrastrong sulphide waters must not be used in the treatment of humans because their concentrations may cause serious complications and may even prove lethal.

Depending on the value of pH, the sulphides contained in mineral waters may have the molecular form of H_2S and the ion form of the hyposulphide ion HS, and also (more often than not) simultaneously both forms. This is why in relation to H_2S and HS sulphide waters can be subdivided into four lesser groups: (1) hydrogen-sulphide waters (when pH $<$ 6.5; H_2S constitutes more than 75 per cent of all sulphides); (2) hydrogen-sulphide-hydrosulphide waters (when pH 6.5-7.0, $H_2S > HS$); (3) hydrosulphide waters (when pH $>$ $>$ 7.5 HS constitutes approximately more than 60 per cent of all sulphides); (4) hydrogen-sulphide-hydrosulphide waters (when pH 7.0-7.5, $HS > H_2S$).

It should be borne in mind that H_2S exerts a stronger effect on the organism than the hydrosulphide ion. The physician must be aware of this when prescribing sulphide waters in which H_2S predominates over HS. We have dwelt on these four examples because

quite often, for no plausible reason at all, sulphide waters are labelled under one term 'hydrogen sulphide'.

Only sulphide waters of active volcanic regions may be regarded as hydrogen sulphide waters along with certain ultrastrong brines which should not be applied for medicoprophylactic purposes. Mineralization is most important in characterizing sulphide waters. The optimum mineralization of sulphide waters, particularly for their external application, can be 20-35 g/l. Carbon dioxide also significantly influences the therapeutic effect because it decreases the value of pH, thus increasing the relative content of free H_2S. An important role also belongs to the microelements Br, I, H_2SiO_3, Zn, Cu, and others, since a portion of them enter the inner medium of the organism together with hydrogen sulphide.

Thus, the cited criteria used in evaluating sulphide waters acquire vital importance for the physician, because these criteria help to choose the appropriate sulphide water for medicoprophylactic purposes.

Some of the subterranean mineral waters contain arsenic. Three types are distinguished: arsenious, ferrous, and 'polymetallic' containing two, three and more metals in different amounts: Fe, As, Al, Cu, Pb, Zn, and others. These elements are formed mainly at the expense of atmospheric waters, and rarely of metamorphosed sea waters. Despite their different genesis, Ivanov stresses that the accumulation in these mineral waters of the above-mentioned metals takes place in all cases as a result of their leaching of rock ores.

Most arsenious waters are carbonate waters of different ion composition and mineralization, which form in areas where deep thermometamorphic processes develop and in which arsenic is sometimes present in large quantities in the form of arsenious acid and the products of its dissociation (H_3AsO_3, H_2AsO_3). Among arsenic-containing mineral waters, carbonate arsenious waters are of the greatest spa-therapeutic value because they help to suppress the activity of the inflammatory process, enhance the trophics of the myocardium and the skeletal muscles, improve cardiohaemodynamics, reduce peripheral resistance, and intensify haemopoiesis.

According to the ion composition of carbon dioxide arsenious waters, predominant are the hydrocarbonate waters of different cation composition, hydrocarbonate-chloride sodium, chloride sodium, calcium sodium, as well as bromine and siliceous waters. They all contain large amounts of carbon dioxide, possess a weak acidic reaction (pH 6.0-6.5) and are characterized by different temperatures (up to 72 °C) and mineralization up to 25 g/l.

Arsenious carbonate waters are used both for drinking and for baths. It is necessary, however, to remember that arsenic possesses a pronounced pharmacotoxic effect; this is why (when drinking is prescribed) the water must be strictly dosaged. Arsenious water con-

taining 0.7 mg/l of arsenic may be taken per os in a dose of one teaspoonful or one tablespoonful. The strict dosage of water in this case is a reminder that the rules of drinking mineral water are similar to those for administering drug solutions. This is a signal for the doctor that natural therapeutic waters render a pharmacotherapeutic effect, and there must be a strictly differentiated approach to their application.

Arsenious mineral waters are classified into three groups according to their arsenic content: (1) arsenious (arsenic) 0.7-5.0 mg/l; (2) strong arsenious (arsenic) 5.0-10.0 mg/l; (3) very strong arsenious (arsenic)—more than 10.0 mg/l. In bottling mineral water the permissible content of arsenic is up to 3 mg/l, and in therapeutic drinking water to 1.5 mg/l.

Ferrous waters form an independent group of therapeutic waters. Besides high concentrations of other metals, some of them contain a lot of iron—from hundreds to thousands of milligrams per litre. Ferrous waters must contain no less than 20 mg/l of iron. Ferrous waters are also divided into: (1) ferrous waters with a concentration of 20-40 mg/l; (2) strong ferrous waters with 40-100 mg/l; (3) very strong ferrous waters with concentrations of over 100 mg/l.

Ferrous waters are prescribed per os in cases of iron-deficient anaemias, hypo- and anacid gastrites, chloroses in girls, colitides, etc.

The first group of ferrous waters includes nitrate, weakly mineralized, acidic, sulphate or hydrocarbonate-sulphate waters, genetically linked with the oxidation of the sulphide minerals of iron. The second group is characterized by nitrate, weakly mineralized waters and waters of complex ion composition. Genetically this group is linked with Quaternary, and more rarely with other deposits. Lastly, the third group consists of carbonate, mainly hydrocarbonate waters developed as a result of carbonate leaching of various ores. It should be noted that in Italy 'polymetallic' waters are successfully used at spas and bottled as therapeutic mineral water. Acqua-Forte is designated by the expression

$$M_{7.4}\frac{(SO_4+HSO_4)\cdot 100}{Fe_{67}Al_{15}}\ pH\ 3.2\ T\ 11\ ^\circ C$$

Iodobromine waters are genetically linked with chloride waters of marine origin. Oceanic water of normal salinity (mineralization 35 g/l) has a content of bromine 65 mg/l, iodine 0.05 mg/l, and chlorine 19.3 g/l. The enrichment of subterranean waters with iodine does not depend on the mineralization of water, but is genetically linked with marine, mainly clayey, deposits containing considerable amounts of organic substances.

Vinogradov (1967) is of the opinion that the accumulation of iodine in marine silts is determined by the content of dispersed organic substance composed of the remnants of vegetation and animal orga-

nisms which had concentrated iodine taken from marine water in the process of their life activity, as well as by the amount in them of decaying substrate which had absorbed iodine as the deposits accumulated. The extraction of iodine from rocks by porous and subterranean water takes place as a result of the thermal disintegration of dispersed organic substance (at temperatures of 100 °C and higher) and the subsequent processes of dissolving, leaching and diffusion of organic and mineral iodine compounds. In distinction from humic acids iodine is desorbed from clayey particles due to the presence of fulvic acids in the water.

Krainov and Shvets (1980) have noted that regenerating processes and the alkaline reaction of waters are conducive to the accumulation of iodine. As a result, iodine in various forms may accumulate in subterranean waters; these forms are: molecular (I_2), ion. in the forms of iodide (I^-) and iodate (IO_3), as well as the complex form with organic substance. The correlation of the molecular and ion forms of iodine depends on the value pH: in the acidic medium I_2; in an alkaline medium $I^- + IO_3$. The content of iodine in subterranean mineral waters and brines may, according to Kudelsky (1976), reach several hundred milligrams per litre. In the opinion of the author, with the increase of the geological age of the deposits, the content of iodine in underground waters decreases and, on the average, constitutes 33.1 mg/l in the Cenozoic waters, 18.4 mg/l in the Mesozoic, 19.5 mg/l in the Paleozoic and 7.6 mg/l in the Precambrian waters.

Iodine and iodobromine waters are primarily used as drinking mineral water. The concentration for bromine water is 25 mg/l. Formerly the norm of iodine content in mineral waters was set at 10 mg/l, but such an amount was considered reduced, because each prescribed dose was 5 mg/l (Ivanov, Nevrayev, 1964). At a mineralization of over 10 g/l waters may be regarded bromine or iodine only if, after they are diluted with fresh or weakly mineralized water to the established mineralization, the content of Br and I in them does not fall below the conditional level. Iodobromine chloride waters, sometimes hydrocarbonate chloride sodium waters, are of relatively less mineralization (up to 25-50 g/l) and are characterized by the predomination of bromine over iodine. Iodine waters, which are usually chloride and chloride-hydrocarbonate and not of high mineralization (15-25 g/l), are rarely encountered

There is a higher content of silica in many types of underground mineralized waters. Its highest concentrations are found in thermal and high-thermal waters. A large amount of silicic acid is typical for acidic waters containing CO_2 and particularly free H_2SO_4 and HCl. In all cases the accumulation in subterranean mineralized waters of large amounts of silicic acid is the result of the leaching of rocks containing SiO_2. In mineral waters silicic acid is expressed as

H_2SiO_3. Its high concentration is determined in thermal waters, mainly of the four genetic groups:

1. Nitrate, weakly mineralized alkaline therms. Widespread in Bulgaria, Italy, USSR, France and many other countries. They form in crystalline rocks at considerable depths at high temperatures and pressures. Nitrate alkaline therms are distinguished by low mineralization (less than 1 g/l, rarer 1.5-2 g/l) and by clear alkaline reaction (pH = 8.0-9.4). The high content in them of silicic acid (up to 140 g/l) determines their therapeutic value in external application. These therms are not for internal use due to the high content of fluorine which when accumulated exerts a negative effect on teeth and bones.

2. Nitrate-carbonated, chloride, superheated (temperature above 100 °C) water of moderate mineralization (up to 5 g/l). Forms in areas of modern active volcanism. The content of H_2SiO_3 reaches 200-300 mg/l, particularly in Kamchatka and Kuril islands, in Japan, Iceland, New Zealand, and other countries. Such therms are widely used in the construction of geothermal power plants.

3. Carbonate thermal waters, which form in regions of young magmatic activity, in rocks of various composition. Mineralization up to 5 g/l, content of silicic acid reaches 200 mg/l. Widely used for both external and internal application.

4. Fumarole therms, acidic. Located in areas of modern volcanism. Contain high concentrations of H_2SiO_3 (up to 400 mg/l), and also Fe and Al. The balneotherapeutic value of silicic acid was first recognized in the USSR in the 1930s in nitrate weakly mineralized alkaline therms. The lowest level of silicic acid content is 50 mg/l. Three groups are currently distinguished according to silicic acid content: (1) siliceous waters with 50-100 mg/l of H_2SiO_3; (2) highly concentrated siliceous waters containing 100-150 mg/l; (3) very highly concentrated siliceous waters with a silicic acid content of more than 150 mg/l.

Many mineral waters contain certain amounts of organic substance of various composition and origin. In most cases underground waters leach organic substance out of water-containing sedimentary rocks, particularly bituminous ones. Part of the organic substance may seep into the subterranean waters with the surface water, which contributes to the forming of underground waters.

The content of organic substance is maximum in waters of gas-oil deposits, where it may reach several hundred milligrams per one litre. Acetic, formic and other aliphatic acids prevail in petroleum waters. Moreover, esters, spirits, amines and carbohydrates may be found in other types of waters. Fulvic and humic acids predominate in the humus substances found in surface waters of peat-rich land. It has been established that organic substances acquire major importance in forming the chemical composition of mineral waters.

Germanov, Panteleyev and Shvets (1975) have pointed out that organic substances take part in biochemical processes forming such waters, in creating various complex and element-organic compounds during chemical redox processes, and influence structural changes in the water.

In assessing the content of organic substance in therapeutic waters, one must bear in mind the total content of organic carbon, including carbon in volatile and non-volatile substances. These waters are characterized by a low mineralization (up to 1 g/l) and a high content of organic substance (up to 20 mg/l).

Clinical observations and special research reveal that mineral waters containing organic substances have a very favourable effect in treating diseases of the hepatolienal system, first and foremost in cholelithiasis, renal, urinary and metabolic diseases, particularly in diabetes mellitus, uratic diathesis, gout, and other diseases.

In characterizing mineral waters one must take into account their acidity and alkalinity, which are evaluated by their pH level (pH is the symbol denoting the negative logarithm of the concentration of the hydrogen ion in gram atoms per litre; it expresses both acidity and alkalinity). Thus, pH helps to locate weak acids in subterranean waters, as well as to determine the presence of heavy metals in them. The value of pH may change in these waters within very wide limits from 0.5 to 9.5.

Ivanov and Nevrayev (1964) found that a strong acid reaction ($pH < 3.5$) is defined in two groups of mineral waters, namely, (1) in fumarole therms of active volcanic areas where there are free H_2SO_4 and quite often HCl, and (2) in sulphate waters of the oxidation zone of sulphide deposits containing free H_2SO_4. An acid reaction is typical of fumarole therms and strong brines containing large amounts of Ca and Mg.

A weak acid reaction (pH 5.5-6.8) is inherent in carbonate waters with a small content of mineral salts. Waters with a neutral reaction (pH 6.8-7.2) and also of a weak alkaline reaction (pH 7.2-8.5) represent a wide variety, including sulphide waters. An alkaline reaction (pH 8.5-9.5) is characteristic of nitrate siliceous therms in which there is no carbon dioxide at all. Strongly acidic and acidic waters are rarely used in balneotherapy. They are used at the Kisly Klyuch therms on the Soviet island of Kunashir and at the fumarole therms in Japan. Weakly acidic and neutral or alkaline waters affect the organism in different ways. Weakly acidic waters enhance the function of the sympathico-adrenal system. This is important in the treatment of patients suffering from dystrophic diseases. Neutral, or weakly alkaline waters, on the other hand, are effective in inflammatory diseases.

Uranium (U), radium (Ra) and radon (Rn) are often found in subterranean mineralized waters. Therapeutically, radon waters are

most valuable (gas with a half-life period $T_{1/2} = 3.825$ days, with alpha-radiation). The short-living products of radon decay (Rn A, Rn B, Rn C) provide certain interest. Rn A ($T_{1/2} = 3.05$ min), Rn B ($T_{1/2} = 26.8$ min) and Rn C ($T_{1/2} = 19.7$ min) can form an active deposit, mainly at the cost of alpha- and beta-radiation. The accumulation of a considerable amount of radon in water occurs mainly at the expense of radium which is contained in large amounts in one form or another in water-absorbent rocks. The quantity of radon is far less than the amounts of any other gases existing in the waters. Radon, therefore, never determines the basic gaseous composition of mineral waters. Radon in water exists only in a dissolved state and does not create spontaneous gases.

The therapeutic effect of radon is accomplished by its alpha-rays, as well as by the active deposit intensifying the effect of radon, which forms as a result of the precipitation of the products of radon decay (Rn A, Rn B, Rn C).

According to the international system of measurements the unit of radon concentration is the Becquerel which corresponds to one nuclear transmutation per second (1 Becq $= 1\ s^{-1}$). This unit may be applied in a cubic metre (Becq/m^{-3}) or in a litre (Becq/l). Since various units of radon measurement have been applied, we provide their equivalents:

1 unit Mache = 3.64 eman = 0.364 nanocurie/l= 13.5 Becquerel/l;

1 nanocurie/l = 10 eman = 2.75 Mache units = 37 Becquerel/l;

1 Becquerel/l = 0.027 nanocurie/l = 0.27 eman = 0.074 Mache units.

In recent times radon waters are considered to be those which contain Rn $>$ 5 nanocurie/l (or 14 Mache units, $>$ 50 eman, $>$185 Becquerel/l). Depending on the concentration of radon in the water four groups are distinguished, each of which is conditionally known by its own concentration:

(1) very weak radon waters with 5-20 nanocurie/l;

(2) weak radon waters with 20-40 nanocurie/l;

(3) medium concentration 40-200 nanocurie/l;

(4) radon waters of high concentration, more than 200 nanocurie/l.

Clinical observations show that patients react unfavourably to radon waters of high concentrations. Aggravations develop, particularly in inflammatory diseases, and there may be cardiovascular disorders, tinnitus cerebri, etc. This is why the prescription of radon waters of high concentrations is contraindicated for patients suffering from whatever diseases. The most pronounced therapeutic effect, particularly in cardiovascular disorders and in elderly people, is achieved with the use of radon waters of weak concentrations. Such waters may be applied in inflammatory diseases even of medium severity and in functional diseases.

Radon waters of medium concentration may be prescribed for people under fifty with diseases of a dystrophic nature, and also after bone and joint injuries without signs of thrombophlebitis or other diseases of the peripheral vessels. The range of radon concentration in this group of waters is very wide, namely, from 40 to 200 nanocurie/l; consequently, their prescription may be differentiated. For example, patients suffering from the hypertensive disease (stages IB and IIA) may be successfully treated with baths containing water of 40-120 nanocurie/l radon concentration and those suffering from rheumatoid arthritis may be given baths with a radon concentration of 40-80 nanocurie/l, and so on.

There are two major groups of natural radon waters: (1) waters of 'simple' composition, in which radon is the sole component producing a therapeutic effect with the water, and (2) waters of 'complex' composition, in which radon is combined with other therapeutic components. The waters of the first group are genetically linked with the upper fissured zone of acidic crystalline rocks with an increased content of radium, and are, in essence, phreatic waters. The waters of the second group are genetically linked either with rock uranium-radium mineralization, or with secondary accumulations of radium of an adsorptive character. These waters are usually of the following types: nitrous thermal weakly mineralized, highly mineralized chloride, carbonate, of various ion composition and temperature, as well as nitrous cold, chloride waters, and brines. This group of waters provides the most interest for medical practice because the therapeutic effect is accomplished not because of the radon alone, but due to the peculiar complex comprised of mineral salts which intensify the effects of both radon and the products of its disintegration. It should also be noted that radon waters may be produced artificially by saturating fresh water with radon liberated from a radium compound specially prepared for it.

Last but not least, the factor of temperature is of considerable importance for the therapeutic application of mineral waters. The water may be heated to the required temperature when used, but the temperature of natural mineral waters varies in a wide range from low to high, at times gets even as high as 250°-300 °C (particularly in a region of active volcanism). The temperature of the water depends on two factors: the thermal regime of the bowels of the earth and the depths at which the water circulates.

According to temperature, mineral waters are divided into seven groups: (1) Extremely cold and very cold waters, located mainly in the northern areas of our planet. These are highly mineralized and brine waters which cannot be used for treatment because of their temperature. (2) Cold waters with temperatures ranging from 4°-20 °C. These are waters of shallow circulation (up to 300 m) of continental and mountain-fold regions. Such waters can be bottled or

used in baths after heating. (3) Warm waters with a temperature of 20-35 °C belong to the category of subthermal waters and may be utilized in basins or, when heated a little, in swimming pools. (4) Hot waters (~35-42 °C) are categorized as thermal waters and used in therapy and prophylaxis. It should be borne in mind that the optimal temperature is 38-39 °C, therefore, hot waters must be heated to such temperatures by means of special balneological equipment. (5) Very hot waters (42-100 °C) and exceptionally hot waters (over 100 °C) located in areas of modern active volcanism, including geysers. They are of greater national-economic importance than of therapeutic value.

Along with their physicochemical characteristics, the sanitary evaluation of mineral waters is of substantial importance. This is why the prohibitive criteria, particularly for drinking mineral waters, are so high. In the first place, the water cannot contain more than 0.4 mg/l of vanadium, 1.5 mg/l of arsenic, and 0.02 mg/l of mercury; in the second place, the optimum doses of trace elements must remain within the following limits: lead 0.3 mg/l; selenium 0.05 mg/l; strontium 2.0 mg/l; fluorine up to 5 mg/l. In the third place, chromium and uranium are permissible in amounts up to 0.5 mg/l, radium up to $5 \cdot 10^{-7}$ and phenols up to 0.001 mg/l. Arsenic is, however, an exception since its content in water for drinking is allowed up to 15 mg/l. But these waters are not prescribed by the glassful, but by the teaspoonful or tablespoonful. All mineral waters used for medical purposes must conform to sanitary norms. The total amount of bacteria in water both for internal and external application must not exceed 100 per 1 ml of water. The coli-titre of drinking waters must be no less than 300 and for external application (baths) no less than 100. Moreover, an important sanitary index is the low content of nitrates, nitrites, and ammonium which should not exceed 50.0, 2.0 and 2.0 mg/l, respectively. It is necessary for the physician to have a thorough knowledge of the physicochemical structure of various waters so that he may quickly and correctly distinguish between the many types.

Kurlov's formula is applied for the structural representation of the chemical composition and physical properties of mineral waters. At the beginning of this formula the specific components are introduced, including gases in g/l, Rn in nanocurie/l, and sulphide waters in mg/l; the mineralization (M) of water is then introduced (in g/l) and its ion composition, equivalent per cent in the form of a conditional fraction, with the anions in the numerator and the cations in the denominator. The values of pH and the temperature of the water are introduced at the end of the formula.

This formula has been changed with time and is currently known as the formula of ion and gaseous composition.

The formula of gaseous composition

$$\text{Specific gases (g/l)} \quad G\,\frac{\text{spontaneous}}{\text{dissolved}}\,\text{(mg/l)} \quad \text{Composition of gases} \quad \frac{\text{spontaneous}}{\text{dissolved}}\,\text{(vol.\%)} \; T\,(^\circ C)$$

$$H_2S\ 0.280\,\frac{170}{288}\,\frac{CH_4\ N_2\ CO_2\quad 17}{H_2S\ \ S\ \ 46\,^\circ C\ \ 02\ \ N27}$$

Formula of the ion composition of water

$$\frac{H_2S+HS\ 0.426\ \ M27}{Br\ 0.066\quad I\quad 0.008}\,\frac{C197\quad HCO_3 2}{(Na+K)\ 8\ Ca\ 13}\ pH\ 6.7,\ T\ 39.0$$

This means that we are dealing with very strong sulphate (hydrosulphate hydrogen-sulphide) water, of a complex gaseous composition (nitrogen-methane-carbonate-hydrogen sulphide), with a moderate gas content, aerated, iodobromine, highly mineralized, chloride sodium weakly acidic, thermal.

Besides mineral waters, therapeutic muds (peloids) are of substantial medicoprophylactic importance. They constitute a homogeneous thinly dispersed plastic substance consisting of water, mineral and organic components which together possess certain thermal properties (high heat capacity and heat retention, and low thermal conductivity).

In origin, on which their properties and composition to a large measure depend, therapeutic muds are divided into definite genetic types, namely, peat muds, saprophagous, sulphide silt muds, clayey, and volcanic muds. Sulphide silt mires, saprogenic and peat muds are most frequently used in mud therapy.

Therapeutic peats consist mainly of decaying organic substances and the putrid vegetation of swamps. There are not many minerals in peats. According to the mineralization of liquid peat mires, they are divided into fresh-water and mineralized muds.

In strongly acidic peats mineralization may reach 250 g/l and more. Sapropelite bed load deposits are predominantly of organic composition with a small admixture of mineral substances forming for the most part in fresh-water reservoirs as a result of the microbiological disintegration of algae and other vegetation, as well as animal fragments and residues.

Aeroheliothalasso-therapy and aero-ionotherapy belong to the climatic factors playing a major role in comprehensive physiotherapy. The effect of climatic factors on the organism is measured by their parameters such as atmospheric pressure, the intensity of electric and magnetic fields, radioactivity, wind velocity, humidity, the character of solar radiation, the number and correlation of negative and positive ions of air, aerosols of air saturated with marine chloride sodium salts, and so on.

The methods of climatotherapy are biologically grounded means for stimulating the life activity of the organism; they are natural stimulants under the influence of which various physiological regulating mechanisms developed in the process of evolution (among them are the neurohumoral mechanisms of regulation which are connected with the production of histamine in response to the effect of solar radiation, the systems of physical and chemical thermal regulation, and others).

In conducting climatotherapeutic procedures, aerotherapy in particular, the thermoadaptive mechanisms are trained, which leads to hardening of the organism and the strengthening of its links with the environment. As a result of regularly conducted aerotherapy, the thermal asymmetry of different skin areas is decreased, reaction to cold is reduced, metabolic processes become normalized and stimulated, including redox processes, in view of which aerotherapy may be considered a method of natural oxygen therapy.

Climatotherapy is a physical method promoting the restoration of the disturbed function of the cardiovascular, respiratory and certain other systems which are of paramount importance in the process of rehabilitation. An important role in the responsive reactions of the organism is played by precisely those organs and systems which are influenced by various climatic factors. The effect of aerotherapy is predominantly aimed at the system of thermoregulation, in conducting heliotherapy—at the sympathico-adrenal system, etc. Climatotherapy is a pathogenetic method of treatment. At the first stages of a hypertensive disease it is conducive to lowering the arterial pressure and increasing the contractile function of the myocardium, at the early stages of atherosclerosis it helps to normalize lipid metabolism, and so on.

In prescribing climatotherapy at health resorts of different countries it should be taken into account that persons suffering from certain chronic diseases of the cardiovascular and bronchopulmonary systems, of the joints and spine, the stomach and intestines react to sharp changes in climate, particularly at the start of acclimatization. The patient's reaction may give rise to predominantly cerebral, cardiac, vegetative-vascular, arthralgic, gastric and other kinds of symptom complex depending on the specific features of the primary and concomitant diseases and the peculiarities of the new microclimate. Climatic reactions may be sharp, just as in the case of stress, or be of the character of disadaptive meteoneurosis.

In distinction from the above-mentioned natural medicinal means, physicotherapeutic factors also include certain natural phenomena which have been converted by man into various forms of energy: electric current, electrical and magnetic fields and their combinations, the artificial spectrum of solar radiation, mechanic oscillations, artificial aeroionization, and the like.

To build a scheme of treatment which will include the most efficacious combination of natural factors, one must understand, knowing the physicochemical characteristics of these factors, how the given factor affects the biochemical, physiological and other processes in the organism in a given disease. In some instances these factors may produce an adequate response and have a favourable effect on the course of the disease, if their dosage accords to the level of the general reactivity of the organism; in other cases when the dosage of the factor is changed, i.e. the method of its application, or if the method is the same but changed due to the unfavourable reactivity of the major functional systems of the body (lowered, heightened or disturbed) these factors may cause an unfavourable therapeutic effect. Such an assessment of the effect of a given natural factor, however, merely reflects the general conception of the interrelations between the organism and the given therapeutic means.

When planning combined therapy for a patient suffering from a dystrophic or inflammatory process, it is also important that the physician knows the mechanism of the healing effect of the natural or transformed factor.

The therapeutic effect of the physical factor begins from the moment of its contact with the patient. In some cases this contact is made through the direct application of mineral water, therapeutic muds or the use of climatotherapeutic factors which effect the cellular and neurovascular elements of the skin and mucous membranes. In other cases the different components of these factors influence the cellular structure of the respiratory tracts, the neurovascular, and glandular apparatus of the gastrointestinal tract, and, in still others, some components give rise to respective reactions in distant analysers.

The components of mineral waters, therapeutic muds and the air around us come into contact with numerous nerve endings in the organism. In the protein structures of these formations, among the anions, cations and biologically active substances, complex reactions develop (at the molecular level). These reactions developed over the course of thousands of years because nature, and particularly its extreme influences, caused considerable changes in various functional systems of the organism. As a physiological means of defence, the activity of certain physiological systems was intensified in man, while the function of others was relaxed. This system of regulation and restoration of disturbed functions of the body has developed throughout the history of mankind.

Chapter 3. The Man-Nature Relationship

Over the course of evolution nature prepared man to bear up to the various influences of his environment and to establish permanent contacts with changing environmental processes.

During thousands upon thousands of years certain biological rhythms developed in accordance with the activities of different functional systems of the body; moreover, these rhythms changed parallel to changes in the environment. On the basis of scientific data established for the most part in the 20th century, in our age of scientific and technological progress, it has been proved that the living cell with its complex biological structure and metabolic processes has existed for more than three billion years. The biological conversion of the simplest organisms and animals at various stages of development took place according to a principally new type of adaptation as compared to the primary stage of their origin.

At birth every man has genetic factors which have been determined in the process of evolution. This evolution is very clearly evidenced in the unusual living conditions of the most ancient of men. It was established, for instance, that 8 million years ago Ramapithecus was the most ancient ancestor of man (Dubinin, 1977).

It is known that man as we know him now, *Homo sapiens*, appeared 30,000-40,000 years ago and the progress of his development was initially defined by social factors.

Labour proved to be a mighty factor in the development of personality. Man, including his consciousness, talents, emotions, health, etc., was formed in the process of social labour. An important role in this process belonged to the system of speech signals by means of which certain stimulants of the environment influencing the psychic activity of man and changes in the function of his quick-adaptive systems are transformed in the cerebral cortex. The Australopithecus (southern ape) lived about 2.6 million years ago and began walking on two feet in an upright position because the conditions of the environment changed including the landscapes, climate, the location of seas and oceans. This is why the erect posture of the Australopi-

thecus is interpreted as his adaptation to changes in the environment. The cranium capacity of Australopithecus was 500 cc. In *Homo erectus* (man in an erect position) this capacity increased to 1250 cc. When the direct ancestors of modern man appeared (200 000 years ago) the volume of the brain was 1500 cc (Dubinin, 1977).

Man created tools of production with intent and used them in nature, taking part in transforming it. This long and complex development strengthened the ties between man and nature even more.

The environment of man is often regarded merely as the natural medium in which his evolution took place. This is why S. Botkin (1888) and then I. Pavlov (1908) in defining the term 'disease' proceeded from the premise that the essence of disease consists in a disturbed balance between the external and internal living conditions of man. At the same time, people in their relationships create many problems themselves, which are, at times, more complicated than those with which nature confronts them. This is particularly important to bear in mind in our age of scientific and engineering progress.

Physical and mental health or illness is determined to a great extent by the role played by production relations, family life, friends, co-workers, and the social conditions within the society. The World Health Organization (WHO) maintains that health does not only signify the absence of disease and physical defects, but that it is a state of complete physical, spiritual and social well-being. This definition, however, does not reveal the meaning of disease or the mechanism of its development and fails to explain how to preserve health.

S. Burenkov, the USSR Public Health Minister, very briefly but aptly outlined the ways by which health can be safeguarded: 'The improvement of the people's health protection is achieved by everyday organizational work and a vast number of concrete accomplishments of all kinds.'* These accomplishments must be directed at the development of medicobiological and social measures necessary for strengthening the health of people.

Clinical data testify that social conditions such as poverty, which still exists in many countries of the world, and various situations of stress (death of relatives, personal conflicts, dramatic events) upset the balance of man's relationships with people among whom he lives, and may trigger the mechanism of some disease.

Different people suffer in different ways from the death of relatives, from parting with close friends, which causes psychosocial stress and emotional disturbance. Moreover, unfavourable circumstances may arise, and such troubles add to the emergence of various diseases. But not all people become ill under these circumstances. This

* *Zdorovye*, 1981, No. 5, p. 4.

means that not only do the above-mentioned reasons give rise to disease, and there are even factors which have the opposite effect. The most important of these factors are the inherited and personal qualities of every individual.

It has been noted, for instance, that in the same family various diseases of the spine may be inherited (the father, son, grandson and great-grandson), Bechterew's disease, for one. In another family, on the other hand, the given inherited disease does not always occur in subsequent generations (only the father was ill and none of the other relatives). In still another family a congenital heart disease was inherited or the predisposition for the development of rheumatism, gastric or duodenal ulcers, and so on.

The personal qualities of an individual play a major role in the origin and development of many diseases, particularly those which are connected with the genetic code and inherited. Man thus possesses, first, certain congenital qualities, and secondly, under the influence of the environment he acquires labour habits. These qualities and habits to a certain degree determine the characteristic features of a person. This is why I. Pavlov in his time contended that the character of a person should be regarded as an alloy of congenital and acquired qualities. Such typical qualities may also influence the predisposition of some people for the appearance of some disease or, on the contrary, in certain instances they may help to protect one's health.

Emotional stress occupies a very special place among the causes which lead to the impairment of health and the development of certain diseases. Unfortunately, all the mechanisms which affect a person in stress situations have yet to be made clear but the facts speak out for themselves. The death of close relatives, unhappy marriages, the birth of a deformed child, the loss of a job often lead to the development of various diseases.

On returning from the cemetery after the funeral of her husband, a patient of mine experienced general weakness and pain in her right leg. The next morning, first her right leg became acutely swollen, then her left one; there was aching pain in her thighs and perineum and the function of the lower limbs was disturbed. An assessment of the state of the patient and the results of special blood tests gave grounds for the diagnosis of acute thrombophlebitis (inflammation of the major veins) of the lower limbs. There were no other reasons (infection, trauma, physical overstrain, etc.) for the development of this acute inflammatory process in the veins besides severe psychic trauma. The psycho-emotional stress exerted a substantial influence through the central and vegetative nervous systems on the coagulative and fibrinolytic blood systems and the tonus of the vessels. This actually determined the beginning of the thrombolytic and inflammatory processes, the clinical manifestation of which became acute

thrombophlebitis which developed further into a severe affection.

Women suffer terribly in giving birth to a deformed child. Such stress is conducive to the development of a neurosis with obsessive states, manic-depressive psychosis, exacerbation of rheumocarditis, and so on. WHO statistics show that the mortality rate of widows and widowers immediately after the death of their spouse is ten times higher than that of other persons of the same age groups. The morbidity rate of people in the first year after a divorce is about 12 times higher than that of married people of the same age and status.

Besides stress which might be termed 'of a personal character' there are other harmful factors influencing our health. These include the pollution of the environment, particularly of the air, rivers, lakes, seas and oceans, as well as lands where grain is grown, where cattle are herded, etc. The origin of diseases known to man may be linked to city and industrial noises. They cause over-excitation of the nervous system, which results in various clinical manifestations of neuroses, particularly stage IA of the hypertensive disease. Industrial sewage, radiation, floods, and earthquakes also exert a harmful influence on human health.

Epidemiological research on the spread and causes of non-infectious diseases, particularly cardiac ischaemia, diseases of the joints and spine, gastric and duodenal ulcer, and hypertensive disease, testifies that on a level with the above-mentioned causes, the factors of risk are just as significant.

The risk factors are harmful agents which do not cause a disease, but aid its formation and clinical manifestation, especially if such factors combine with others. Fatty foods, alcohol, smoking, and high arterial pressure are risk factors in relation to the development of heart diseases. Each of them to a certain degree promotes ischaemic heart disease, but if such factors combine, the probability of development of the disease increases manifoldly. More than 50 risk factors promoting the development of ischaemic heart disease are currently known. Other risk factors (psycho-emotional influences, poor-eating habits, smoking, and so on) play an important role in the development of peptic ulcers or the hypertensive disease, still others (immobility, excess body weight, local infection, psychic trauma, colds, and others) play a part in the development of deforming arthrosis or rheumatoid arthritis. There are risk factors which encourage the development of diabetes mellitus, nephrolithiasis or cholelithiasis, and so forth.

The existence of risk factors which are capable of triggering the onset of different diseases does not mean, however, that these diseases will necessarily occur strictly because these factors are present. The role of these factors may be so insignificant that it is practically impossible to trace them. In view of this the question arises: what determines the possibilities for the inception of so many diseases?

Most likely these possibilities are harboured in man himself. In other words, when the resistance of the organism to such unfavourable factors of the environment is weaker than the disease agents' mentioned, their influence brings about a discord between the regulatory defensive systems of the organism, the influence of unfavourable factors is not sufficiently resisted, and the disease develops. This is an extremely complicated process, but unless it is comprehended in every concrete case it becomes impossible to grasp even a general idea of the mechanisms inducing the given disease. The physical, social, economic and other factors of the environment in which people live and work influence their health and their susceptibility to disease. These factors also determine to what extent a person is capable of changing his habitual behaviour so as to adapt himself to whatever difficult conditions of the environment might arise.

The factors impairing health and the mechanisms inducing the onset of a disease, just as the mechanisms of man's ability to adapt to environmental conditions, have not been sufficiently studied. Depending on how well they are understood, we can adjust our methods for improving health and preventing the development of a disease.

One must know the functional anatomy of man to understand how various diseases of the heart and vessels, stomach or liver, joints and spine develop, since besides a concept of the development of a disease, it is most essential to take into account the specific changes occurring in the organs in a given functional system under some unfavourable effect.

The numerous diseases of man which develop under the influence of various external and internal conditions possess something in common, as they all involve either breakup of the physiological mechanisms in the activities of the nervous system, the irregularities in the functions of the adaptive systems, or, lastly, according to I. Pavlov, disorders in the physiological arsenal of protection against a disease. As a result of such disorders, three large groups of diseases may form which we conditionally distinguish as functional, inflammatory and dystrophic diseases. In each of these groups the disease, in its clinical manifestations, will affect a certain organ more than others, depending on which system of the body is most affected. There is one kind of clinical picture in dyskinesia (disturbed function of motion) of the biliferous system, for instance, and another kind in centrogenic cardialgia, and a third in the angioneurotic form of stenocardia (retrosternal pain) or the beginning stage of arterial hypertension. All of these diseases are based on functional disorders of the central nervous system of the type of neurosis with its manifestations specific to organs in various systems.

This principle of division has proved to be expedient in studying the largest group of diseases which involve the inflammatory process.

Certain clinical changes have been recorded in cholecystitis (inflammation of the gallbladder), others in pneumonia (inflammation of the lungs), still others in arthritis (inflammation of the joint) or spondylitis (inflammation of the vertebra). Altogether different clinical and biochemical changes are noted in nephritis (inflammation of the kidneys) or hepatitis (inflammation of the liver), etc. They all have in common the process of inflammation, however, which is characterized by regular patterns both in its development and course, as well as in progress and outcome. There are also specific features of medicobiological and sociological nature. In nephritis, hepatitis or carditis (inflammation of all membranes of the heart) or in pneumonia the outcome may be death, but in arthritis, spondylitis, or radiculitis (inflammation of a nerve root) or prostatitis (inflammation of the prostate) such an outcome is less probable, but the patients will be sick for a long time and their temporary incapacity will last longer; moreover, many of the patients may become invalids.

Diseases of a dystrophic nature develop in more than half of all people. The dystrophic process (disturbed nutrition of tissues) may occur in any organ: the liver, kidneys, heart, stomach, joints, spine, skeletal muscles and spinal cord, causing specific changes in the organism which produce different clinical manifestations of the disease.

In some diseases inflammatory and dystrophic changes combine and become manifest in various clinical syndromes against the background of which functional disorders may also occur, or, on the contrary, other clinical forms of diseases may be produced by functional and inflammatory changes resulting later in dystrophic disorders. Either way, these three large groups of diseases must be studied from clinico-pathophysiological and morphological aspects, because they form the basis of human pathology. We avoid mentioning tumour pathology here on purpose, because there is much that remains obscure and questionable in the aetiology and pathogenesis of tumours that calls for further intensive research.

Thus, it can be stated that various diseases develop as a result of disturbed interrelationships between man and nature. In some people diseases of an inflammatory nature occur from which their ancestors had suffered, in others dystrophic and functional diseases develop caused by constitutional factors; these diseases affect this or that organ or system respectively dependent on the hereditary factor. Finally, in a third group of people various combinations of these diseases may form, which are accompanied by attending processes of a different nature.

Years of observation and special research testify that under the influence of natural therapeutic factors (mineral waters, fangoes, climatic conditions, particularly fresh air, sun- and air-baths) the impaired processes taking place in the body are restored and a per-

son again becomes practically healthy. It is quite obvious that patients suffering from various clinical forms of diseases (of which more than a thousand have been registered) could not have recovered just from the effect of radioactive, carbonate or hydrogen sulphide waters alone. Hundreds, possibly thousands of types of waters would be required to produce such a therapeutic effect. This means that there is an inner connection, i.e. complex pathogenetic mechanisms, linking thousands of forms of diseases. The effect of the mentioned waters helps to regulate and restore the disturbed functions so that the pathological process weakens or disappears altogether.

It is well known, for instance, that patients suffering from ischaemia of the heart, hypertensive disease, radiculitis, neuritis, arthritis, arthrosis, spondylitis, or osteochondrosis are treated with sulphide waters which have a favourable therapeutic effect in all such patients.

Each patient, of course, is prescribed these waters differently (according to the concentration of hydrogen sulphide, the temperature of water, the time and frequency of intake) and in combination with other means (physical training exercises, regulated activity, massage, sea bathing, etc.), but the main factor is nonetheless hydrogen-sulphide water. Therefore, it is obvious that sulphide water bathing exerts an influence on different mechanisms in the development of the three groups of diseases to which the above-mentioned nosological forms belong.

Carbonate, hydrogen-sulphide, and radon baths, mineral springs and mud therapy may be successfully used in treating patients with inflammatory, dystrophic and functional diseases. There are hundreds of such clinical forms of diseases which can be cured at spas; fundamentally their development and clinical course depend on the mechanisms which lead to the inception of the three big groups of diseases mentioned above.

Hydrogen-sulphide and radon baths produce an excellent therapeutic effect in ischaemia of the heart and hypertensive disease, rheumatoid arthritis and deforming arthrosis, ankylosing spondyloarthritis and intervertebral osteochondrosis. Waters at mineral springs produce a wonderful effect in treating gastric and duodenal ulcers, in functional and inflammatory changes in the biliferous system, colitis and proctosigmoiditis (inflammation of the descending portion of the large intestine), etc.

The question naturally arises: how can the influence of these natural factors on such different forms of diseases be explained? The mechanism of action of all these waters has one purpose: the regulation and restoration of the disturbed functions of the organism, although the principal links involved in the process of their action in the above-mentioned forms of the disease are quite different. These differences are determined, on the one hand, by the physicochemical struc-

ture of natural factors, and, on the other hand, by the reactivity of the organism which develops differently depending on the clinical form of one of the three above-mentioned groups of diseases.

The research of recent decades has shown that irrespective of the mechanism which triggers the development of inflammation (infection, trauma, nervous or physical strain, and so on) an important role in its development and progress belongs to functional disorders of the nervous and adaptive systems, as well as to the development of auto-immune processes. These processes and neurohumoral disorders are the main mechanisms of inflammation, because they determine the essential transformations which take place in the body as a measure of its defence against disease.

The processes and mechanisms of developing inflammation in different organs are extremely complex and determined by the specific properties of the organs of various tissues. The structure of the liver, for example, includes parenchymatous cells (hepatocytes) which fulfill very complicated functions (production of bile, the synthesis of carbohydrates, fats and proteins, participation in regulating water-salt metabolism, etc.), and to a large degree differs from the structure and function of an articulation, for instance. The articulation consists of a bone-cartilage foundation and soft tissues: synovial membrane, fibrous capsule, ligaments, fat bodies, nerves, arterial, venous and lymphatic vessels. Each of these elements contains connective-tissue cells, osseous and cartilaginous structures which differ from the above-mentioned cellular structures in that (1) osseous tissue has a lace-like structure which includes osseous cells (osteoblasts) promoting the growth of bone, and cells (osteoclasts) which absorb bony tissue; that (2) blood arterial and venous capillaries and precapillaries, lymph collectors supply bone cells with plastic and energy materials and ensure the evacuation of the products of metabolism (metabolites) into the environment, and that (3) the cells (chondrocytes) of the epiphyseal cartilage which plays an important absorptive role in the activity of joints are located in the connective-tissue frame. The cartilage itself contains neither nerves nor vessels and its nutrition consists of synovia (produced by the synovial membrane), and of blood serum supplied by the capillaries of the end part of the bone adjoining the epiphyseal cartilage. These processes are accomplished by osmosis and diffusion.

Because of these 'architectural' and functional complexities the metabolic processes in chondrocytes are slowed down and their endurance in relation to loads is considerably greater than that of other tissues. The anatomophysiological peculiarities of the liver and of the joints provide evidence of the sharp difference in the structure and function of these organs. The life and activity of every cell in them is also different: different cellular membranes and different

receptors in them, different cellular enzymes and cellular respiratory apparatuses (mitochondria), peculiarities of metabolism, as well as distinctions in reproduction and in resistance to unfavourable factors, different responses to the influences of inner and external media. Still greater distinctions may be noted in the structure and function of these and other organs such as kidneys, the heart, stomach, intestines, skeletal muscles, and so on.

It is quite understandable that the inflammatory process develops differently in these organs and systems, though the trigger mechanisms of its development may be the same. It is very important for the integral whole to keep the nervous and adaptive systems always alerted, because they are the first in defence and bear the brunt of unfavourable environmental factors. This defensive reflex was developed during the process of the evolution of the organism.

If the resistance of the organism is sufficiently strong, the breakup of its physiological means of defence against disease occurs less frequently and the consequences of detrimental factors are less pronounced. It was precisely during the process of evolution that man adapted to the natural factors which exerted a favourable influence on the rehabilitation of the disturbed mechanisms regulating the vital activities of the organism.

The ocean of air surrounding us, the rays of sunshine and the water on land expanses form, in essence, the environment in which *Homo sapiens* originated and developed into the man that we speak of in our times. This is why the above-mentioned components of the environment became inalienable elements in the life and activity of the human organism. Life would be impossible without oxygen, water, and solar rays. Take away oxygen from the air cloak covering man and he will perish; deprive him of water and the processes of his metabolism will cease; place him into a room deprived of sunshine and his metabolism will decrease sharply just like the resistance of his organism to the detrimental influences of the environment. It is important to know, however, which elements of nature should be utilized in various diseases, otherwise exacerbations and further aggravation of health may follow. Moreover, if one does not know the essence of the effect produced by natural factors in such cases, the effect may be fatal. Mineral waters, therapeutic muds, sunbathing or intensive physical loads when prescribed incorrectly for patients suffering from rheumocarditis, for example, may cause exacerbation of the process and lead to severe consequences. In patients with latently developing tuberculosis of the bone or joints disseminated tuberculosis may occur and the result may be tragic.

At first glance it seems strange how natural factors with which man has been bound throughout his evolution can result in such severe consequences. Years of observation and special research have proven, nonetheless, that any natural or transformed factor must be

applied in doses corresponding to the functional state of the patient's organism, otherwise, the condition may be aggravated.

To gain an understanding of the essence of this exacerbation, let us discuss rheumocarditis which is known for the complex processes which comprise the disease. The significance of these processes boils down to the destruction of collagen in the connective tissue of all the cardiac membranes and the inception of auto-immune chain reactions which induce the advance of the disease. The inflammatory process in the pericardium (the outer sac of the heart), the myocardium (the middle, or muscle membrane), and the endocardium (the inner layer of the heart) has a beginning and an end. A substantial role in the inception of the process, along with the congenital predisposition of the heart for the development of a variety of diseases, belongs to the beta-haemolytic streptococcus of group A which most often passes directly to the heart from the tonsils or from carious teeth. Moreover, the toxins of these microbes may enhance the sensitivity of membranous receptors, muscle and connective-tissue cells of the heart and, under the influence of detrimental factors (psycho-emotional stress, physical strain, colds or unfavourable conditions of work), lead to the development of an allergic state, the clinical, electrocardiographic and biochemical manifestation of which becomes rheumocarditis. The development of this process is, of course, far more complex (see below) but we are providing a brief concept of the mechanism of its development (Monaenkov, 1979) for the reader to gain some understanding of the inadequate action of natural factors on rheumocarditis patients.

Let us presume that rheumocarditis in some patients is of moderate or high activity with severe clinical manifestations, i.e. inflammation in the membranes of the heart is fairly acutely pronounced, the destructive process in the connective tissue is quite rapid, and immunocompetent (mainly lymphatic) cells accumulate in the focus of inflammation; the redox processes in them take place at a relatively high level and, at the same time, we add the influence of sulphide baths. What happens in the organism at this time? In which direction will the inflammatory process progress? There are no simple answers to these questions. In the first place, under the influence of a course of treatment with sulphide water, the heat balance in the organism is disturbed since thermoregulation due to lesion of the vegetative nervous system in rheumocarditis patients is already disturbed while the effect of this warm water reduces heat emitting ability and increases body temperature. In the second place, under the effect of sulphide water the flow of impulses along the nerve endings of the skin and mucous membranes to the central nervous system becomes intensified. This, in turn, together with intoxication of the organism, intensifies dysregulation of muscular contractions causing more frequent heart contractions. In the third place, under the in-

fluence of sulphide water the absorption of hydrogen sulphide by the cells of the myocardium is also intensified. Absorption mostly concerns the sulphhydryl groups and trace elements in these waters which become involved in metabolic processes, intensifying redox reactions, activating immunocompetent cells and thus boosting the inflammatory process in the cardiac membranes. In the fourth place, sulphide waters noticeably stimulate the hormonal link of the sympathico-adrenal system, which, in turn, activizes the process of inflammation. Last but not least, these waters do not enhance the glucocorticoid function of the adrenal cortex, and with the increased expenditure of steroids during inflammation the balance of these hormones becomes disturbed and their anti-inflammatory and immunodepressant effect is decreased. All this leads to an intensification of the inflammatory process, a decrease in the resistance of the organism, the activation of endogenous infection, the aggravation of the general condition of the patient with all the undesirable consequences.

If, instead of a course of sulphide baths, the rheumocarditis patient is given a course of high- or superhigh-frequency electromagnetic waves according to a specially devised system of methods, then, on the contrary, the synthesis of corticosteroids in the adrenal cortex will be intensified, dissociation (dismemberment) of the protein-steroid complex will take place and free steroids will be released which, in turn, will have a favourable effect on the course of the disease. This has been confirmed by clinical observations and by the quantitative assay of various fractions of steroids. After a course of such treatment the main syndromes of rheumocarditis become less pronounced, including the syndrome of hypocorticoidism (a decrease in the level of corticoids in the blood), because the content of the total, free and bound hormones, i.e. the products of the adrenal cortex, increases. Moreover, these reactions influence the tonus and the reactivity of the sympathetic nervous system which changes in particular the non-specific immunological resistance (stability) of the organism while increasing overall resistance. In essence, these two levers of neurohumoral regulation change the course of rheumocarditis.

How do these reactions change the nature of the course of the disease?

Special research established that increase in the function of the sympathetic nervous system leads to the suppression of the autoimmune chain reactions and to a weaker process of collagen destruction in the connective tissue which lies between the muscle cells of the heart, as well as to an increase in the non-specific immunological resistance of the organism. The strengthening of the glucocorticoid function of the adrenal cortex, the release of free steroids and reduction of the binding ability of transcortin exert, on the one hand, a depressive influence on immunocompetent cells, i.e. suppress their

functions (moreover, these cells are scattered in different layers of the heart). On the other hand, the corticoids thicken the membranes of the cellular structures of the heart. As a result of these changes the permeability of the tissue, including the capillary structures, decreases, which in turn leads to a lesser exudative component of the inflammation. At the same time the glucocorticoids produce a direct effect on the fibroblasts (connective-tissue cells) and suppress their growth. This reduces the proliferative component of inflammation.

Thus, as a result of the effect of sulphide water on patients suffering from active rheumocarditis, the inflammation process in the heart is intensified, which, in turn, reduces intracardiac haemodynamics, exhausts the function of the heart muscle, diminishes the blood supply to the vital organs and systems, primarily to the brain, liver, kidneys, and other organs. This may lead to the decompensation and dysregulation of their function, to the development of hypoxia and severe intoxication with a dramatic outcome. On the other hand, the timely inclusion of high frequency electromagnetic effects in the complex of therapeutic measures may save the life of such a patient, suppress the process of rheumocarditis and lead to practical recovery.

If patients with latently developing tuberculosis, particularly in the joints, which is rarely diagnosed in good time, are prescribed natural therapeutic factors, an aggravation of the process may occur during treatment, as well as various complications, even with a tragic outcome.

How is this explained? What is the mechanism of the origin of this process?

Clinical observations show that after cooling and particularly after trauma of the bones and joints, arthritis or post-traumatic arthrosis develops in patients. Such patients are treated for a lengthy time but with no clinical effect. After trying all the known antirheumatic drugs and other methods of treatment, even of folk medicine, without achieving a positive result, the patient is sent for spa treatment. On his arrival at a health resort, particularly if he is sent from an in-patient establishment of a large city, the physicians prescribe natural therapeutic factors, mainly mineral waters and healing muds. After receiving six to eight sulphide or radon baths according to the method accepted at the given spa or five to six mud applications, the patient develops a balneological reaction, i.e. the response of the vital functional systems to these procedures (quickening pulse and respiration, general fatigue, increased pain in the joints, slight fever, etc.). Usually on the 8th to 10th day this reaction develops into an exacerbation of the process, but there are cases when this inflammatory process is characterized not only by local (in the joint) changes, but by general clinical manifestations. Body temperature in patients rises to 39 °C-40 °C, the skin covering the affected

joint becomes warm, the general condition of the patient becomes worse, headaches, pains in the chest and affected joints (or joint) appear; the patient starts coughing and finds it hard to breathe, etc. In such cases physicians usually discontinue the baths to start looking for the causes of this state and begin drug therapy. In some cases, except for the exacerbation of the inflammatory process in the joint, nothing else is revealed. In other cases local disorders in the joints are paralleled by substantial changes in the lungs, the X-ray picture of which together with the results of biochemical blood tests (high erythrocyte sedimentation rate [ESR]), leucocytosis (increased white cell count), different levels of C-reactive protein, sialic acids, changes in the interrelationships of blood protein fractions and so forth, provided grounds for a diagnosis of disseminated pulmonary tuberculosis.

The study of the case histories of such patients, of clinical and X-ray changes in their joints give reason to suspect that in the past they had suffered tuberculosis of the bones and joints (most often of the knee and hip articulations) which had been in a phase of remission (a tranquil condition) when the patient was admitted to the sanatorium. Under the effect of sulphide or radon baths, however, the local process in the joint was activated. It is well known that such baths improve the blood supply to the synovial membrane which contains tubercle bacilli, *Mycobacterium tuberculosis*, intensify the influx of biogenic amines (histamine, serotonin), as well as of adrenaline activating the life of mycobacteria there. Simultaneously an active reaction of histiocytic and lymphocytic cells develops and, with the weakened resistance of the organism the accumulation of tuberculosis mycobacteria in the bronchopulmonary system leads to the spread of the tuberculous process in the lungs. To suppress this process modern antituberculosis drugs are used (including para-aminosalicylic acid, streptomycin, tubazid, phthivazid, rifampicin).

In most patients complications are overcome, but in some patients, despite intensive treatment, the disease nonetheless takes a chronic course. Thus, such a chronic process may, under the unfavourable influences, eventually be exacerbated.

The cited data testify that it is very difficult to define the character of the disturbed relationships between the internal and external media of the organism. It is no less difficult to determine the prophylactic and therapeutic measures that should be taken to restore the impaired functions of the organism and establish normal relations between its internal and external media.

No less complex are the developmental mechanisms of numerous diseases of a dystrophic nature. The process of the weakening of the adaptive-trophic function of the sympathetic nervous system against the background of disturbed corticovisceral interrelations is of principal importance in the development of these diseases. In other

words, these are disorders in regulation by the cerebral cortex of functions of the internal organs (stomach, biliary system, intestines, etc.) as well as local disorders in different organs and systems of the body.

Corticovisceral disorders in humans occur mainly as a result of stress which leads to a clash of the stimulating and inhibitive processes in the cerebral cortex and to the development of neurosis with disorders of the functions of the cardiovascular and biliferous systems, disturbances in the activity of the stomach, intestines, kidneys, etc.

Bykov and Kurtsin evolved the corticovisceral theory of the origin and development of gastric and duodenal ulcers. The basic premise of this theory is the idea that due to the impairment of the normal processes of inhibition and stimulation in the cerebral cortex a d the resulting disturbance of correlative links between the latter and subcortical ganglions, primarily the ganglions of the hypothalamus, such complicated diseases develop as peptic ulcers, the first stage of the hypertensive disease, neuroses of the heart and stomach, dyskinesia of the gastrointestinal tract, and others. Since the endocrine glands become involved in the active sphere of the corticovisceral reflex, in abnormalities of the nervous system the pathogenesis of these diseases is promoted by a powerful hormonal system which is responsible for a lengthy process and the stability of pathological changes in the activity of the viscera.

Gastric or duodenal ulcers develop under the influence of long, constantly acting centrifugal (most often psychoemotional) impulses causing the spastic contraction of muscles and blood vessels of the stomach wall in general trophic disturbance of cellular and tissue activity. The result is a weakening of the mucous membrane's resistance and its subsequent digestion by gastric juice.

Bykov believed that there is no such thing as gastric and duodenal ulcer, but only an ulcerous disease as a systemic disease. Disorders which take place in the complex entire system of the body are conducive to or precede the appearance of gastric ulcers. This is why the origin of the ulcerous disease should be regarded as a new, stable complex of corticovisceral reflexes, as a newly created pathological link connecting the cerebral cortex with inner organs. It is extremely difficult to destroy this link and eliminate the dystrophic process in the viscera, particularly in the stomach. In view of this, the application of natural factors acquires important medicoprophylactic significance. These factors are capable of uprooting the pathological inertness, enhancing the trophic function of the organism and eliminating disturbances which are essentially the source generating pathological impulses and sending them continuously to the central nervous system.

In recent years greater importance is attached not only to cortico-

visceral links, but to neurohumoral shifts. Dyshormonism (disturbance of the hormone secretions) which occurs in gastric and duodenal ulcers, local secretory, hormonal and enzymatic processes against the background of such neuroreflex changes lead to stable trophic disorders which form the basis of disturbances in the function of the stomach, intestines, liver, and pancreas. Development of various complications including haemorrhages is also possible, as well as disorders in evacuating the contents of the stomach due to cicatrization of the pylorus, and its dilatation which results in the inception of a variety of syndromes and an unfavourable outcome.

The pathogenetic mechanism of the dystrophic process in the myocardium, stomach, or joints is not identical in all these diseases, although there are many common features. To gain a comprehension of these diseases, let us dwell briefly on the pathogenesis of the dystrophic diseases of joints.

The dystrophic process in the joints originates mainly as a result of a decrease in the adaptive-trophic function of the sympathetic nervous system. The decrease of this function develops under the effect of either extreme physical overstrain or a sharp reduction in the mobile activity of a person (hypokinesia). In the first case there is a change in tonus and reactivity of the vegetative nervous system as a result of physical overloads (particularly in ballerinas, professional athletes, manual labourers, timbermen and coal miners, etc.). This builds up the hormonal but weakens the sympathic links of the sympathico-adrenal system, which, in turn, causes trophic disorders primarily in the synovial membranes, fibrous capsules and the ligament apparatus of the joints, as well as in the internal organs.

How do these changes originate? What is their ultimate result? What prophylactic measures should be taken?

The ups and downs of the tone of nerve fibres which innervate these organs and tissues cause disorders in their blood supply, congestion of venous blood, particularly in the venous link of the capillary system, disorders of metabolism in the cellular structures of the synovial membrane, first and foremost in the synoviocytes. With the progression of neuro-vascular disorders and because of the organ-specific peculiarities of these tissues, the entire capillary system undergoes changes (the capillaries shift from the periphery to the depths of the membrane and become depleted), the circulation of the fluid in the cell itself and in the intercellular spaces is impaired. The decreased transportation of energy and plastic materials, hormones and trace elements, vitamins and salts, as well as the disturbed evacuation of metabolites advance the dystrophic process in the synovial membrane, disturbing its function: the membrane reduces the production of synovial fluid considerably, which is extremely necessary for the nutrition of the epiphysial cartilage. Moreover,

people in whom atherosclerosis of the vessels is forming, particularly in the vessels of the limbs, exhibit atherosclerotic changes in the capillaries of the metaepiphyseal portions of the long tubular bones participating in the formation of the joint, which ultimately results in the depletion of the capillary network in various tissues of the joints. In the long run the epiphyseal cartilage is deprived of nutritious materials and the dystrophic process sharply intensifies. Under such unfavourable conditions the cartilage dehydrates and constant loads cause cracks to appear with the development of subchondral osteosclerosis, that is, the supracartilaginous calcification of bone trabeculae. Osseous proliferations (osteophytes) grow which, in their turn, aggravate the course of the disease of the joint. The cellular structures destroyed in this process form antigens, which are substances participating in the development of aseptic (non-infectious) inflammation of the synovial membrane of the joint.

In patients suffering from hypokinesia, i.e. insufficient mobile activity not only of the locomotor system, but of the stomach, intestines, biliferous and emictory, cardiovascular and bronchopulmonary systems, etc., the metabolic processes are slowed down. In such patients fatty regeneration of different tissues develops, primarily of the synovial membranes of joints, the outer coat of the heart, myocardium, kidneys, liver. The fatty tissue is accumulated both in the internal organs and in the subcutaneous tissue. The increased weight of a person by 30-40 kilograms becomes a constant surplus weight which has a detrimental influence on locomotor functions, produces microtraumatic effects conducive to the manifestation of secondary synovitis which develops against the background of an aseptic inflammation.

Moreover, a sedentary way of life and a decrease in the adaptive-trophic function of the sympathetic nervous system is conducive to the congestion of blood, particularly in the capillaries which supply energy and plastic materials to the joints and evacuate residues. This, in turn, obstructs the discharge of metabolic products and is favourable for the origin of hypoxia (deficit in supplying the cells with oxygen) and acidosis (accumulation of acidic products of metabolism), both of which aggravate the dystrophic process and advance deforming osteoarthrosis.

Similar mechanisms form the basis for the development of intervertebral osteochondrosis, a dystrophic process taking place in the shock-absorbing disks lying between the vertebrae. Due to anatomic peculiarities in the structure of the spinal column changes occur, on the one hand, in the intervertebral articulations, and, on the other, in the intervertebral nerve roots. As the intervertebral disk dries, cracks appear in it, and sometimes its pulp seeps out, i.e. its contents; this may give rise to severe complications, particularly when part of the pulpous nucleus drops between the vertebral body and the

spinal cord into the cerebrospinal fluid. This causes a block which obstructs the circulation of the cerebrospinal fluid, making it necessary to perform surgery. The dystrophic process results in desiccation of the intervertebral disk, which reduces the height of the disk, approximates processes participating in the formation of intervertebral articulations, and leads to the development of a dystrophic process in them. The formation of this process is simultaneously accompanied by the compression of the nerve root and its vessels which disturbs the blood supply to the intranerve fibres. This results in the development of hypoxia, dystrophy and an inflammatory process in the root, its membrane, its epidural space (between the membranes), and in the fatty tissue, which in the long run determines the character of the manifestation and the severity of radiculitis.

The picture of the neurological manifestations of the disease, the involvement in the process of the internal organs (heart, stomach, intestines), of various parts of neuromuscular and skin areas depends on the degree to which the intervertebral disks (cervical, thoracic or lumbar) are affected. All types of sensitivity (temperature, tactile, pain), as well as motor and coordination activity, are impaired to a different degree.

It is quite understandable that the developmental mechanism of the disease defines the tactics for applying natural therapeutic factors. Mineral water baths, mud therapy, transformed physical factors (ultraviolet long-wave or short-wave radiation, sinusoidal modulated currents, supersonic, decimetre-wave therapy), physical training exercises and massage are all of substantial importance in curing patients. In orthopaedic and particularly pronounced staticodynamic disorders, however, it would be expedient to include underwater-vertical traction, underwater-horizontal sagging and orthopaedic-surgical measures which, taken together, can slow down the progress of the disease and prevent the loss of working capacity and invalidity.

There exists no doubt that the problem 'Man and Nature' comprises many very complex problems of medicobiological character since they are connected with the development of different diseases and the use of natural factors for the purpose of health rehabilitation and the prevention of diseases which ultimately lead to incapacity and premature death. At the same time, the task of rendering the natural environment conducive to good health and the rational use of natural factors have acquired major sociological importance because such measures greatly decrease the frequency of disturbed contacts between man and nature, and the vital components of nature can be used for the regulation and restoration of impaired functions of the organism. Man's care for nature will bring its rewards because the removal of sources of air and water pollution (rivers, seas and oceans) on the

Earth's surface will reduce the negative influences on society while the rational use of different natural factors will help to improve the health of millions of people on our planet.

To understand the most complex processes taking place in the organism, however, and to clarify how natural factors influence the regulation and restoration of human health, it becomes necessary to be at least briefly acquainted with functional anatomy. This will help the reader to comprehend the essence of various diseases and make timely and effective use of nature for medicoprophylactic purposes.

Chapter 4. Connection Between Systems Controlling Vital Activity and Systems Supplying the Organism with Energy and Formative Materials

The complexity of the relationships between man and his environment is not only determined by his close ties with the surrounding world without which life would be impossible, but by the fact that man comes into contact with other people in the process of production and particularly in his personal life. Although ties of the first order are hard to control, however, their essence becomes gradually revealed, making it possible to eliminate some diseases and improve living conditions. Ties of the second order are more complicated and even more difficult to control because they are established between individuals, between citizens of either one or several countries of the world. This is why the issue of systems controlling the organism actually has two aspects: control of vital activity of the organism and control of relations between people personally and in society. The latter aspect of the problem is no less complex than the former because it is far more difficult to control the second signalling system, i.e. control the words, thoughts and actions, of another individual than to control one's own thoughts and actions under normal circumstances. It is particularly difficult to grasp the complex of these questions when they concern people of a whole society.

How can we imagine the structure and functions of the systems controlling vital activity and supply of the organism with formative and energy materials?

The principal role in the system controlling the vital activity of the organism belongs to the nervous system, actually to the cerebral cortex and subcortical formations which, in the process of the evolution of man, underwent not only considerable anatomical, but major functional changes. Moreover, these changes which took place over the course of millions of years had a telling effect on the genetic codes of cellular structures, primarily on the cortical and subcortical cells. They were transmitted genetically by heredity. These genetic changes occurred as a result of man's never-ceasing struggle against the unfavourable conditions of his environment; they became perfected in the struggle for existence and were reflected correspond-

ingly in the development of conditioned- and unconditioned-reflex connections between all the systems and organs performing the vital activities of the organism. It may be said that man subconsciously subjugated these organs and systems within the limits necessary for maintaining normal vital activity not only to survive but also to reproduce and work, etc.

Man is a social being. The goal he strives for, and the labour he performs to achieve his goal bring him happiness, joy and satisfaction. This constitutes the source of his vigour and health. Whenever life goes on without a purpose, without creative work and the emotional evaluation of accomplishments, labour fails to bring satisfaction and becomes a pattern of monotonous and exhaustive processes. The famous physiologist Anokhin emphasized that labour is the most humane manifestation of all the activities inherent in people. Labour created and formed man as such, but labour is just one of the links in the complex mechanisms making up a human life. Labour is always preceded by a goal, to be more precise, the reflex of a goal, as Ivan Pavlov called it. It would be impossible to give a clearer and more apt explanation of the tremendous role played in human life by the nervous and adaptive systems designed to help accomplish this goal. These questions have been worked out theoretically and practically. The function of adaptive systems, primarily of the hypophyseal-adrenal, hypophyseal-thyroid (thyroid gland), sympathico-adrenal, hypophysial-ovarian or ovarian systems, and also the vegetative, including the sympathetic nervous system, in controlling metabolic processes and various functions of the organism is of paramount importance. It had long been considered that these glands play a major role in the vital activity of the organism as a separate system of internal secretion and they were regarded exclusively from the viewpoint of the endocrinologist, i.e. of a specialist engaged in the study of the clinical features of diseases of the endocrine glands. In the last few decades it has been established that not only do such diseases cause serious disorders affecting the vital activity and the clinical course of various somatic diseases, but also cause changes in the functions of the endocrine glands in other diseases.

It is now well known that hypocorticoidism develops in rheumatoid arthritis, rheumocarditis, systemic sclerodermia, and dermatomyositis (hypocorticoidism signifies a hypofunction of the adrenal cortex, which determines the clinical peculiarities of the course of these diseases). Without making up for the deficit of steroid hormones it would be impossible to suppress the activity of the collagenic process, to halt the destruction of collagen in the connective tissue and thus induce the remission (abatement) of these diseases. Meanwhile, the adrenals as such are not affected, i.e. the structure of the adrenal cortex is not destroyed as a result of tuberculosis or cancer, circulatory failure, and so on. This is why such diseases, as

for instance, Addison's disease, acute adrenal deficiency or the adrenogenital syndrome (the appearance of secondary male sexual characteristics and inhibited development of female sexual characteristics) do not develop, and there are neither primary nor secondary tumours of the adrenal cortex, etc. Nevertheless, the function of the adrenal cortex in collagenic diseases is undoubtedly disturbed and this is reflected in the course of the disease.

A final decision has not as yet been reached as to how the functional condition of the hypophyseal and adrenal system changes or how this system of control affects the development of various diseases. Nevertheless, some assumptions may be made based on clinical facts and the results of experimental research. It has been established that in persons suffering from rheumatoid arthritis or rheumatism, under the influence of unfavourable factors (infection, particularly focal infection, psychic and emotional stresses, temperature fluctuations, particularly cooling, etc.), corresponding reactions of the frontal lobe of the hypophysis ensue which perform the role of protective-adaptive mechanisms (there is an increased production of ACTH—the adrenocorticotropic hormone). The discharge of ACTH into the blood stimulates the cortical function of the adrenals, activates the synthesis and transportation of 11-oxycorticosteroids which come into contact with the cells, thicken their membranes, reduce the permeability of cellular structures and thus decrease the exudative component of inflammation. The intensified discharge of steroid hormones, particularly of free oxycorticosteroids, suppresses the function of immunocompetent cells both in the myocardium and endocardium (in rheumocarditis), and in the synovial membranes of joints (in rheumatoid arthritis), as well as in the lymphoid system, i.e. in the protective system of the organism. This, without a doubt, serves to protect the organism and saves people from death.

The systems of control suppress pathological processes which arise as a result of stress situations and may induce the development of rheumocarditis, rheumatoid arthritis, systemic sclerodermia, periarteritis, pneumonia, inflammation of the kidneys, etc. It is only natural that these glands cannot produce a sufficient amount of hormones over a long period of time. Therefore, on the one hand, the function of the adrenal cortex weakens and hypocorticoidism develops, and, on the other, due to the potency of pathological agents these diseases take a chronic course.

It should be remembered that the adrenals, located above the superior poles of the kidneys, react very quickly to focal infection. The adrenals are small formations (just 40-60 mm long, 20-30 mm wide and 2-8 mm thick); one adrenal gland weighing from 6 to 11 g.

Aldosterone is produced in the glomerular zone of the adrenals,

cortisol mainly in the fascicular zone, 17-ketosteroids and sex hormones in the reticular zone.

According to the nature of the effect of steroid hormones on metabolic processes, they are subdivided as glucocorticoids and mineralocorticoids. Cortisol, cortisone and corticosterone belong to the former group, aldosterone and desoxycorticosterone to the latter. Each of these hormones performs important defensive and metabolic functions. In the space of 24 hours the adrenals produce 15-20 mg of cortisol, 2-4 mg of corticosterone and 60 mg of aldosterone into the blood. At the peak of functional activity, i.e. whenever there is an emergency condition, particularly when various diseases form, especially of an inflammatory nature, the discharge of cortisol into the blood increases five- and even tenfold. A 24-hour cycle in the production of these hormones is maintained in sufficiently healthy people: the maximum concentration of cortisol is observed at 6 and 9 a.m., the minimum—around midnight. In patients with chronic, particularly collagenic diseases, however, the level of corticosteroids changes due to the weakening of synthetic function of the adrenal cortex: by morning there are far less of them than there had been during the day. It is in the morning that such patients complain of weakness, intensified pains and difficulty of moving. They show signs of pronounced lymphocytosis (increased lymphocyte count in the blood). Tests for the amount of 11-oxycorticosteroids in the blood serum by the fractional method showed the decreased level in the morning of total, bound and particularly of free hormones which play a major role in regulating the clinical course of the disease and steroid metabolism of the organism as a whole.

The synthesizing processes in the adrenal cortex are extremely complex, but there is proof that ACTH secreted by the frontal lobe of the hypophysis flows to the blood and exerts a direct influence on the adenylcyclase (enzyme of the cell) through the receptors of cellular membranes. The production of ACTH is controlled by cortisol, i.e. as if a feedback mechanism is operating here, to be more precise: the secretion of ACTH increases when the level of cortisol in blood plasma goes down and decreases when it goes up. The production of ACTH is decelerated by cortisone, and also by prednisolone and dexamethasone, which possess a glucocorticoid property. The decelerating effect of these hormones on the secretion of ACTH is proportional to their biological activity, first and foremost to the influence over carbohydrate metabolism, their ability to render an anti-inflammatory effect, and so on. Moreover, glucocorticoids injected as substitution therapy cause the weakening of the adrenal function, decreasing the sensitivity of the adrenals to the stimulation by ACTH. Morphological changes develop in the adrenals (they become proliferated by connective tissue, their parenchyma is hypotrophied and they lose their functional activity). This shows how

great the role of the hypophyseal-adrenal link is in the system controlling the organism, particularly in inflammatory diseases.

No less a role in these processes is played by aldosterone. The secretion of aldosterone is regulated by the renin-angiotensin system. Renin is a protein which is produced by the kidney apparatus and acts as an enzyme conducive to the transformation of angiotensinogen into angiotensin I. Angiotensin II is formed out of angiotensin I as a result of biological transformations. Angiotensin II stimulates the secretion of aldosterone from the adrenals and, to a lesser degree, the secretion of corticosterone and desoxycorticosterone. The former possesses an anti-inflammatory property, whereas the latter, on the contrary, intensifies inflammation. Cortisol activates the process of forming carbohydrates out of amino acids. This is necessary for intensifying the effect of adrenaline and glucagon, which mobilize the carbohydrates from the liver, and render an antagonistic effect on the content of insulin in the blood. All these processes raise the level of sugar in the blood (hyperglycaemia).

Hyperglycaemia is, to a certain extent, compensated by the increased secretion of insulin (a hormone of the pancreas), but in increasing the glucocorticoid function of the adrenal cortex under the influence of various reactions or with the injection of like agents, as well as in the insufficient internal correlation of the pancreatic function, steroid diabetes may occur.

It is interesting to note that even after the intravenous injection of steroid hormones into the organism, a large portion of them (more than four fifths) rapidly disappears from the blood only to become manifest, according to experimental data, in the liver cells. When the hepatic function is disturbed, particularly by stress, the process of the formation of corticosteroids becomes distorted and the ability of metabolites to combine with glucuronic and sulphuric acids diminishes. There is also a change in the process of transformation of 17-oxycorticosteroids into 17-ketosteroids which are known to be secreted by the kidneys.

It should be emphasized that transcortin (hydrocortisone, bound with blood protein) is capable of binding corticosterone. These processes are schematically illustrated in Fig. 1.

Cortisol also increases the reserves of fat in the organism because it participates in the production of carbohydrates. Glucose stimulates the secretion of insulin which encourages the synthesis of fat and is conducive to its accumulation both in the internal organs and in the region of the trunk, face, etc. Moreover, cortisol participates in regulating water-salt metabolism. It retains sodium in the organism and intensifies the discharge of potassium with the urine. This hormone can lead to the erosion of the mucous membrane of the stomach, gastric ulcer and often haemorrhages in the stomach. On the other hand, it induces the abatement of the inflammatory pro-

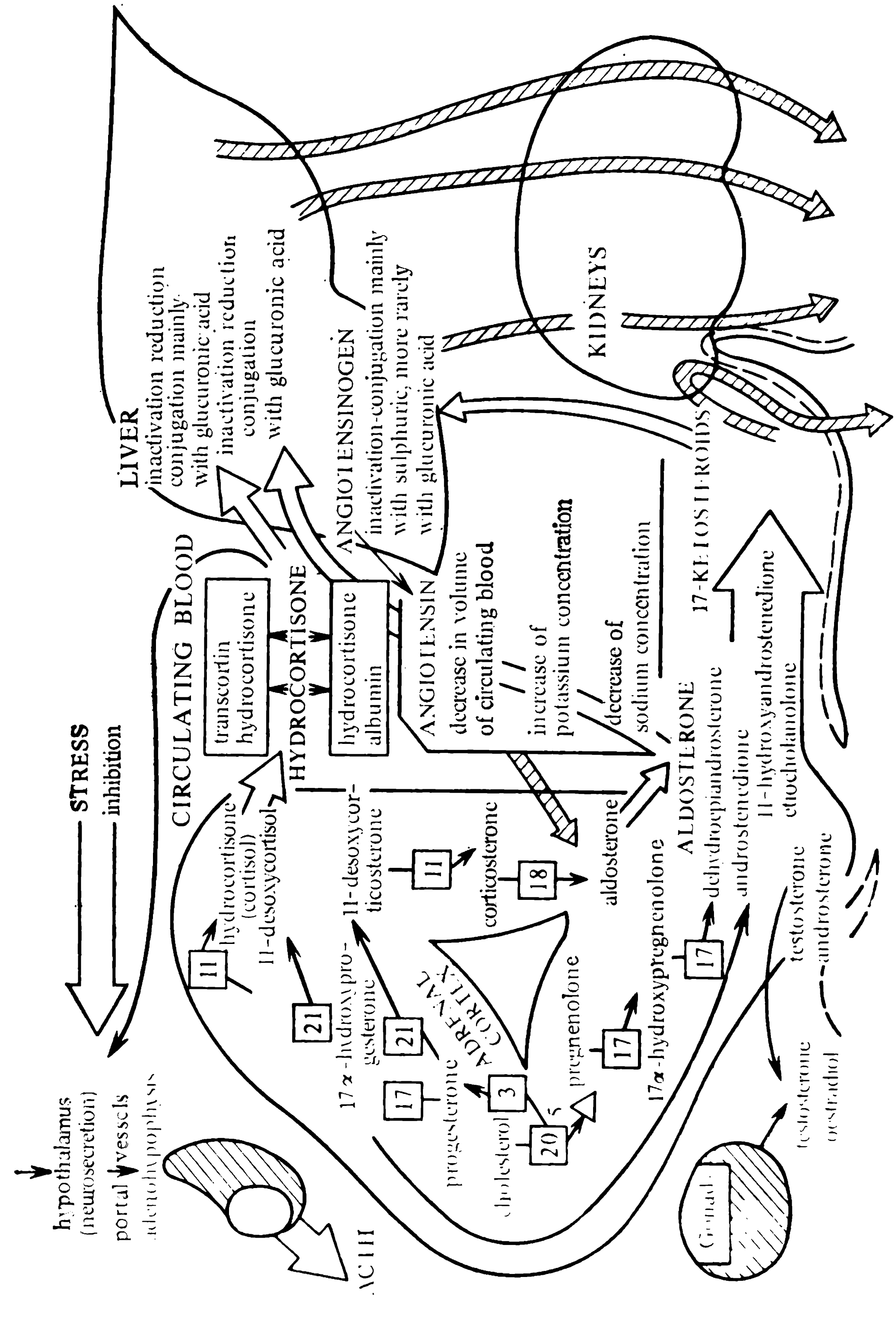

Fig. 1. Scheme of synthesis and conversion of steroid hormones (after Fleishman).

cess in any organ and the inhibition of allergic reactions. In large doses the hormone slows down the production of antibodies, which is significant in inflammatory diseases.

Canadian scientist Selye regarded the varied influence of the hormones of the adrenal cortex as a universal mechanism employed by the body to adapt to unfavourable environmental conditions.

The cited facts convincingly prove the role of the hypophyseal-adrenal system in controlling the main processes in the organism, particularly when a 'break' develops (as Ivan Pavlov puts it) in the physiological means of defence. The central nervous system of man, which is undoubtedly a most ancient and perfect system, controls all the vital processes, including the activity of adaptive systems, but nevertheless these systems, particularly on the 'periphery', in the process of cellular metabolism, primarily in the origin and development of various pathological processes, act to regulate the course of these processes.

The significance of the hypophyseal-adrenal regulating system is determined mainly by the fact that its varied output (hormones) becomes immediately involved in metabolism taking place at organ, cell and molecule levels and ensures the energy and plasticity of the processes developing in the metabolic 'pot' of the human organism. This 'pot' impels and stimulates life because it provides for the exchange of energies, determines the intensity of redox processes and uses formative materials to create conditions for the predominance of creative over destructive processes, for the renewal of cellular structures, and so on.

A no less important role in the course of metabolic processes is played by the thyroid gland. The thyroid hormones secreted by this gland are discharged into the humoral (inner) medium of the organism; they affect various metabolic processes via the metabolic 'pot' influencing the growth and the differentiation of tissues. The decreased function of this gland, particularly its underdevelopment, results in retarded growth and deformations of the skeleton.

Thyroid hormones accelerate synthesis of protein and cholesterol, stimulating carbohydrate metabolism through the 'pot'; they intensify the lipolytic effect of the growth hormone and enhance the effect of adrenaline for mobilizing free fatty acids from fat depots. Intensifying the metabolic processes they increase the requirements of cells in various enzymes and necessary vitamins. The calorigenic effect of thyroid hormones is connected with the segregation of respiration processes and the formation of energy-rich phosphate compounds. Moreover, as it has been established to date, thyroid hormones accelerate the conjugated process of oxidation and phosphorylation.

The function of the thyroid gland is also stimulated by the frontal lobe of the hypophysis, since it secretes the thyreotropic hormone (TTH).

In many human diseases the thyroid gland becomes involved in and regulates the pathological process in different ways. The action of drugs and physical factors on the thyroid gland in inflammatory and dystrophic diseases produces various medicoprophylactic effects. These effects depend on the correlative links between pathogenetic mechanisms determining the clinical course and the progression of these diseases, and on the extent to which the functional shifts of the hypophyseal-thyroid system occur. In rheumatoid arthritis or rheumocarditis, and in chronic pneumonia, a substantial role is played by the hypophyseal-adrenal system, while in gastric and duodenal ulcer dyshormonism is revealed in the glucocorticoid and mineralocorticoid functions of the adrenal cortex. At the same time functional changes of the thyroid gland also occur.

In the above-mentioned inflammatory and dystrophic diseases medicoprophylactic measures, particularly aided by physical remedial factors, are aimed at the adrenals, whereas in an ulcerous disease these measures, particularly decimeter-wave therapy, are focussed at the region of the thyroid gland. Frenkel (1978) demonstrated that an increase in the secretory function of the thyroid gland by superhigh-frequency electromagnetic oscillations produces a favourable effect on trophic processes in the region of a gastric ulcer, changing the secretory and enzymatic processes in the stomach. It is fairly possible that this electromagnetic influence on the thyroid gland also has a telling effect on the functional condition of the sympathetic nodes, primarily on the medium and inferior ganglions of the neck. This, in turn, enhances the adaptive-trophic function of the sympathetic nervous system promoting such processes in the stomach, intestines, liver and pancreas.

An important role in the system of the organism's adaptation to varying environmental conditions belongs to the sympathico-adrenal system which is formed by the cells of the embryonic ectoderm. Two types of chromaffin cells are distinguished: some produce adrenaline, others noradrenaline. Adrenaline is secreted only in the cells of the medullary substance of the adrenals which contain the enzyme phenylethanolamine, which is conducive to the transformation of noradrenaline into adrenaline. Noradrenaline and dopamine are produced not only in the medullary substance of the adrenals, but in other accumulations of chromaffin tissue (in the brain and sympathic nerve endings). These catecholamines are deposited in their own 'mother' cells, i.e. where they are produced, and secreted into the humoral medium under the influence of nerve impulses.

The higher centres regulating the secretion of these neurohormones are located in the cerebral cortex, region of the fundus of the IV ventricle, hypothalamus and reticular formation. The effector link is comprised of the greater splanchnic nerve and nerve fibres coming from various sympathetic plexuses. The release of catecholamines

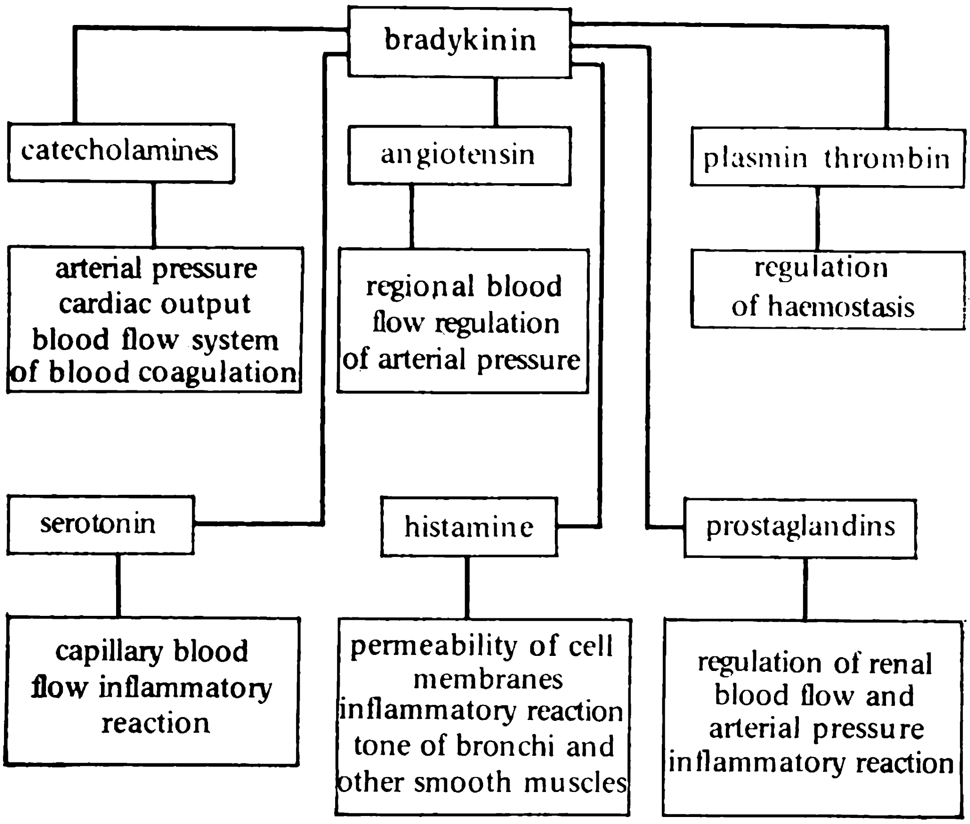

Fig. 2. Scheme of circulatory regulation on different levels (after Dzizinsky, Gomazkov, 1976).

from the cell is stimulated by acetylcholine, the activity of which is maintained by calcium. This testifies to the complexity of the synthesis process and of the adrenaline, noradrenaline and dopamine effect. They circulate in the blood in a protein bound state. This is why, whenever the patient undergoes prophylaxis by means of electromagnetic waves of different frequencies, these complexes dissociate and each of the above-mentioned neurohormones capable of influencing cellular elements is freed.

The increase of cardiac output is also accomplished at the cost of bradykinin. To a certain degree it enlarges the minute volume of the right and left ventricles. In distinction from catecholamines causing the contraction of veins and intensifying the flow of venous blood to the heart, bradykinin dilates these vessels and helps to redistribute blood from the arteries into the veins and to the heart.

This is a very complex process which depends on many neurohumoral components and takes place in certain conjugated interrelations; on the one hand, it is connected with the effect of bradykinin—angiotensin, serotonin, histamine, prostaglandin; on the other hand, of bradykinin and catecholamines, thrombin, plasmin. These relationships are shown in Fig. 2 illustrating which neurohumoral components influence haemodynamic processes and the changes taking place in metabolism in different cells and tissues, how they affect the regula-

tion of capillary and renal blood flows, the change in the permeability of cellular membranes, etc.

Furthermore, adrenaline lowers the tone of smooth muscles in different organs, including the uterine muscles; noradrenaline does not change their tonus; adrenaline greatly stimulates the central nervous system, while noradrenaline has no effect on it, and so on.

The sympathico-adrenal system is closely linked with other adaptive systems: the metabolic effect of catecholamines is intensified by the hormones of the thyroid gland; in hypothyrosis there is a sharp reduction in the glucogenolytic, hyperglycaemic and lipolytic effect of adrenaline, noradrenaline and dopamine. Adrenaline stimulates the function of the frontal lobe of the hypophysis and intensifies the secretion of ACTH. It is interesting that catecholamines interact with corticosteroids in accomplishing their effect on cellular structures, particularly in different inflammatory diseases. It is presumed that corticosteroids intensify the action of catecholamines which increase the production of adenosinemonophosphate. Adrenaline stimulates the production of insulin and the function of the sex glands. These facts are evidence of the close links of various functions of different adaptive systems revealing their mutual influence over the metabolic 'pot' which determines the intensity of the vital activity of the organism and, whenever it is damaged, the possibility of different diseases originating.

Developing immunological processes are important in inflammatory diseases. These processes possess inherent specific and non-specific features, the first of which encourage the advance of the disease because they take part in developing auto-immune chain reactions; the second, on the contrary, are aimed at overcoming non-specific or immune inflammation and enhance the resistance of the organism. All the processes are closely bound with the activity of the thymus gland.

This tiny gland, the function of which has yet to be sufficiently studied, has in recent years attracted the attention of scientists of different specialities who have divulged several of its secrets. It has been established that the thymus secretes the hormone thymosin into the blood. Thymosin stimulates the regeneration of lymphoid tissue. An antigenic differentiation of T-lymphocytes of the gland and of B-lymphocytes of other lymphoid formations is accomplished by the thymus. A connection has been traced between the function of this gland and the processes of haemopoiesis. It is quite possible that the thymus stimulates the formation of lymphocytes. Moreover, an interconnection has also been discovered between the thymus and the pancreas. This connection is demonstrated by the fact that the injection into animals of a lipid extract from the thymus leads to an effect contrary to that of insulin, to be more precise, to a decrease in the content of glycogen in the liver and in increase in the amount

of sugar in the blood. Vitamin B_6 affects the functioning of the thymus and a dietary insufficiency of this vitamin causes involution of the gland in man. It is also known that an extract of the thymus depreciates calcaemia, i.e. lowers the calcium level in the blood, whereas the hormone of the parathyroid gland raises this level. This is why it may be assumed that the hormones of the thymus and parathyroid glands exert opposite effects.

When the function of the parathyroid glands is weakened, the calcium level in the blood drops and the neuro-reflex phase of the secretion of enzymes in the gastrointestinal tract weakens; the same is true of the renal function, particularly in regard to rendering harmless those elements of food which have been absorbed into the inner medium of the organism. The increased amount of the hormone of parathyroid glands in the blood leads to damage of the osseous tissue, reproduction of osteoclasts (cells destroying bone), and a higher phosphatase level. It is possible that the hormone of these glands changes the cycle of tricarboxylic acids, affecting the organic base of the bone and destroying it. Moreover, the influence of the hormone on proline synthesis, which is the main component of collagen, to a certain degree explains disorders of trophic processes in the soft tissues. These trophic disorders coincide with the hypofunction of the parathyroid glands. Their hormones also affect the function of the stomach, kidneys, liver, etc. When the function of the parathyroid gland is impaired considerable difficulties develop in correlating the systems of regulation, as well as in different functional links between the supply systems; the functional ties are disrupted between systems controlling and ensuring the life of the organism.

It is only natural that the systems of digestion and excretion play a major role in the normal functioning of the body, providing it with energy and formative materials. The first system is necessary for supplying the organism with nutrition, including the organs of digestion, and the second system is essential for evacuating metabolites accumulating as a result of the functioning of all the regulatory systems. The assimilation by cells of energy and formative materials, of mineral salts and water, however, can only be accomplished if these elements are split into tiny particles, can enter the inner medium of the organism, and be transported to each cell or group of cells, to each organ and tissue and also if the metabolites are ousted from the cells of organs and tissues of the body. Such processes are impossible without means of transportation and without oxygen. Without oxygen not a single intracellular reaction can begin and carbon dioxide which had accumulated in the process of bioenergetic reactions will not be removed.

All these metabolic and transportation processes are accomplished by the cardiovascular system (the third enumerated). Most likely

it is the primary system since it is a system of vital supply, and it thus controls the supply of oxygen and the evacuation of carbon dioxide which constitutes an indispensable condition of metabolism first and foremost in the cortical cells, i.e. in the cellular structures of the brain which play a primary role in controlling the adaptive systems and regulating the functions of the systems supplying the entire organism.

The supply of millions upon millions of cells comprising different organs and systems with formative and energy materials is a task of great practical importance and at first glance seems uncomplicated because it occurs throughout the entire course of a human life. However, the metabolic process is extremely complex and has not been studied in full as yet. There are many questions which are still not clear in these complex processes. To begin with how is the nutritious mass broken up within the confines of the digestive organs? There is even more to learn about the mechanisms which neutralize and synthesize the proteins, fats and carbohydrates in the internal medium of the organism, and also about the metabolism of these elements at the cellular, subcellular and molecular levels.

The process of providing cells with energy and formative materials presumes the splitting and breakup of foods and their processing at various stages till life is given to the cell and the metabolites are evacuated from the organism. These complex processes are connected by the cardiovascular, blood and bronchopulmonary systems, as well as the hormones, gases, metabolites, biologically active substances, proteins, fats and carbohydrates contained in them. It is only natural that each of the four systems must perform its functions, which may be termed 'social', in regard to the other systems, but at the same time it depends on the functional activity of each of the systems involved. Besides, each system fulfills a specific function: the organs of digestion digest food, the cardiovascular system supplies the organism with oxygen and frees it from carbon dioxide, transports energy and formative materials to the cells and tissues and regulates excretion of wastes from the body. Apart from this, the blood system performs a defensive role: its cellular elements absorb and process the harmful agents penetrating the body, thereby neutralizing them; the excretory system (kidneys, intestines, lungs, and skin) removes the wastes which accumulate as a result of the activities of all the organs and systems, including the excretory system.

Lastly, the powerful locomotor system ensures the mobile activity of the organism necessary for fulfilling the complicated process of movement and of active occupational activity. This system includes the bone and articular apparatus (sacs, ligaments, synovial membranes), powerful skeletal muscles, nerve trunks and major vessels, as well as the vegetative nervous system, arteries, veins,

lymph collectors, capillaries, etc. The system of bones and joints performs the locomotor and defensive functions (protecting the brain, spinal cord and thoracic organs from damage) while the skeletal musculature allows the joints to move and helps the venous blood flow from the periphery to the right heart. It acts as if performing the role of a third factor in circulation. Any occupational activity (physical or mental labour, the labour of a ballerina or pianist, surgeon or sculptor, farmer or metal worker, cosmonaut or seaman, etc.) is accomplished by means of the neuromuscular system. The degree of participation of this system is quite different, of course, in each professional activity, but there can be no room for doubt that it takes part in both physical and mental work.

It should be borne in mind that the functional communication between the systems of control, on the one hand, and the systems of supply, on the other, is characterized not as much by their morphological substrate, which is very complex, as by the neurohumoral mechanisms. These connections are ensured by neuroreflex and neurohumoral processes, the comprehension of which is of both a purely theoretical and of an immense practical interest. To comprehend the role of control systems during physiological processes means penetrating the essence of modern conceptions of life, learning to control these processes for strengthening the health of people. Divulging the connection between control and supply systems will reveal the essence of physiological means of defense against disease. Finally, understanding the pathogenesis of the principal diseases will help to use various means for preventing disease.

In our age of scientific and technological progress there are a vast number of factors which have a detrimental effect on the course of the neurosomatic processes, and which give rise to new diseases. As a result of the productive work of the pharmaceutical industry many new drugs have appeared which, on the one hand, save the lives of millions of people but have side-effects inducing chronic affections often making patients dependent on these medicines. On the other hand, to avoid undesirable side-effects the wider use of natural and transformed physical factors for the treatment and prevention of diseases is necessary.

To understand the complex problem of disease prevention and treatment we must dwell briefly on disclosing its essence and illustrate the effect of natural factors on the human body for the purpose of primary and secondary prophylaxis of different diseases.

Chapter 5. The Essence of Therapeutic Effect of Physical Factors

It is necessary to understand the essence of the therapeutic effect of natural and transformed physical factors on the organism in order to develop the methods for using mineral waters, therapeutic muds, climatotherapeutic, and physicotherapeutic procedures for the treatment of various diseases.

Such natural factors as mineral waters for drinking, mineral springs for bathing, and the application of therapeutic muds, have been used from time immemorial for treating diseases and traumas. Through the centuries, the indications for and methods of using natural factors for medical purposes were established empirically. In the past century enterprisers and then physicians suggested that mineral water should be drunk by the litre (five to ten litres) and over a good length of time particularly for gastrites, colites, diseases of the liver and of the biliary ducts, and also for metabolic disorders. In various diseases of the joints and the nervous system, mineral baths and mud therapy were prescribed in time periods of several hours at high temperatures and with many procedures for each course of treatment. Doctors presumed that the longer the procedure, the more effective it would be. It was considered that under the effect of mineral baths the skin would soften, allowing the easier penetration of elements of mineral water into the body, thus producing the desired medicinal result. Sukhanov (1912) recommended mineral baths for mental patients suffering from catatonic and melancholic syndromes. He contended that such baths of indifferent temperatures for 10-18 hours proved quite successful. Moreover, mineral baths and mud therapy were combined with bloodletting in the belief that such vigorous measures were conducive to ridding the organism of detrimental substances. Several cases have been documented when patients lost consciousness when subjected to such treatment, and, particularly as a result of preliminary bloodletting.

Discoveries in the latter half of the 19th century in physics, chemistry, biology, and microbiology, plus the differentiation of clinical knowledge significantly advanced the study of the therapeutic

effect of natural factors on the organism. On the one hand, these discoveries revealed the physicochemical properties of natural therapeutic factors, while, on the other hand, they helped to develop hypotheses and conceptions of the pathogenesis of various nosological forms.

At the turn of the century many scientists (Belogolovy, 1862; Manassein, 1879; Lozinsky, 1908; Sukhanov, 1912; Fricker, 1840; Duroj and Butruille, 1908; Müller, 1920; and others) who conducted lengthy clinical observations and physiological tests arrived at the conclusion that mineral water is not merely a simple solvent of mineral substances indifferent for the organism, but a very complex combination of mineral salts, gases, and other elements which render a varied influence over the organism. Nonetheless, the essence of the action of mineral waters on the organism remained unclear.

Lozinsky (1910) asserted that the successful therapeutic effect of a number of natural factors such as muds and mineral waters depends on the changes taking place in the skin. In his opinion, muds and mineral waters determine the processes of recovery since they affect the skin before all else, induce metabolic changes, and give rise to complicated transformations in the organism.

He proposed the hypothesis that the products of fatigue accumulate in the organism under the influence of mineral waters and medicinal muds; they activate the metabolism and, according to Weichardt's theory, lead to recovery.

Kaplansky (1938) advanced the opinion that the skin possesses hydrophilic properties which change rapidly under the effect of various types of mineral waters. Changes in the colloidal qualities of skin alter its barrier functions, activating enzymatic processes in the organism, which influences the course of the disease.

In using mineral waters and medicinal muds balneologists attach great importance to the temperature, hydrostatic and mechanical factors which first of all affect the skin-barrier of the organism.

Pogozhev (1904) wrote that while bathing people drink water with all the pores of their body and the thirst of the bathers is thus satiated. This is why attention in studying the mechanism of action of natural factors was focused on the skin. Because of its ramified vascular and nervous system, the skin is not a simple passive filter, but a complex organ performing a defensive function. The mechanism of this defensive function for the organism was not clear.

Sadikov (1919) thought that in mud therapy the high temperature of the mud is important not only because the tissues are warmed, but because a change in temperature alters the effect produced by biologically active substances which change the intensity of the metabolic processes in the body.

Alexandrov (1932) and Rapoport (1934) were of the opinion that the therapeutic effect of mineral waters consists in a peculiar trans-

formation of biocolloids in the organism, and the appearance of biologically active substances in the skin which change the nature of the course of the disease.

Strazhesko and Gubergrits (1931) assumed that under the influence of natural factors there is a change in the protoplasmodynamic processes in the cells which play a major role in the disease development, especially in cardiovascular diseases.

Goldshtein (1937) pointed out that there is not a single chronic disease that can be cured without the participation of the skin, although the specific processes developing in it are still unclear. In stating this, the author stressed that mineral baths are the only treatment which influences all the organs of the human body simultaneously through the skin. This supposition was later developed in the study of natural therapeutic factors.

Sribner (1940) attached great importance to the formation in the skin of histamine-like substances (as a result of mud therapy) which activate the patient's organism. The temperature of the mud to produce such an effect must be at least 50 °C or higher. In this way the author stressed the significance of the thermal factor in mud therapy.

Lozinsky later asserted that during baths the skin is irritated by saline solutions of mineral waters and by active ions.

He wrote that, as he presumed, they had the right to regard the effect of mineral waters, during which the skin and mucous membranes become saturated with various active solutions, as an action similar to the injection of these same solutions into the skin*. He also emphasized that mud therapy, primarily, creates a desensitizing effect. Its essence, in his opinion, boiled down to the effect, produced by the sum total of all the physical, chemical, and biological properties of fango, transmitted by the activity of skin surface areas into the depth of the organism, thereby stimulating the function of all organs and systems. When there is a pathological process the circulation of fluids in the affected tissues is intensified, proteins of exudative origin are washed out during this extremely effective protein therapy, resulting in a favourable therapeutic cure. This viewpoint was seconded by Kukowka (1947).

At the start of the 20th century, much significance began to be attached to the physicochemical properties of mineral waters, particularly to their gaseous, mineral and ion composition, to free and dissolved carbon dioxide, to hydrogen sulphide, and to the anion and cation composition of mineral salts.

In 1928 the research conducted in Pyatigorsk by Ivan Pavlov's assistants (Rickle, Kurtsin, and others) for the first time under ex-

* Lozinsky, *Lectures in General Balneology* (in Russian), Moscow, 1949, 208-217.

perimental conditions showed that the local effect of mineral waters taken per os comes down to the increase or decrease of the secretory function of the principal digestive glands accompanied by the acceleration or deceleration of the peristalsis of the intestines, a change in the evacuation function, etc. It has been established that the specific effect of mineral waters depends both on the initial functional state of the digestive organs, the water temperature, and on the relationship between the time of water intake and the intake of food. Depending on the influence of different ions of mineral water, as well as on their penetration into the blood, there may be general changes in the function of various organs. It is still not fully known, by means of what mechanisms, however, these changes occur.

Until the 1940's and 1950's intensive methods of applying natural factors were used: mud therapy was applied with a high temperature of the mire (50 to 56 °C), and the procedures were very lengthy (up to 30 minutes long). Mineral baths were practiced daily, and were of high concentration and temperature for long periods of time and many times in one course of treatment. This was actually the first stage toward understanding the mechanism of the therapeutic effect of natural factors.

It became obvious that without a new scientific and methodological approach to studying the action of natural factors, without all-round comprehensive clinical, physiological, biochemical, histological and other tests, it would be impossible to disclose the processes which occur during the application of natural and transformed therapeutic physical factors, and, thus, difficult to overcome the routine empirically established and practiced at medical institutions using such therapeutic factors.

A session of the USSR Academy of Medical Sciences, convened in 1950, was devoted to the main trends in the development of Ivan Pavlov's physiological theory and their importance for clinical medicine. In his report given at the session Bykov emphasized that physiological principles were insufficiently applied in the science of spa treatment for uncovering the essence of the therapeutic effect of health-resort factors; that there was no general theory underlying the mechanism of action of natural medicinal factors and that only occasional problems were solved in this branch of science. The cognition of the mechanism of action of natural medicinal factors on the organism calls for the creative use of the theories of I. M. Sechenov, I. P. Pavlov, Vvedensky, and Ukhtomsky about the higher nervous activity, with due consideration for the connection between the nervous and humoral processes occurring in the organism and, moreover, for the close cooperation between clinical, physicochemical, and other branches of research.

Proceeding from the creative application of I. P. Pavlov's theories in clinical medicine, Lozinsky (1953) reached the conclusion that

the mechanism of action of natural factors is based not only on the structural-colloid changes in the skin but is also a consequence of corticofocal shifts. He noted that all processes, pathological processes included, exert an influence on the cerebral cortex and change its functional condition. Balneotherapeutic and climatotherapeutic procedures cause functional changes in the higher centres of the nervous system. These changes combine at certain points of the cerebral cortex with impulses sent from interoceptors, including those with signals coming from pathological focuses. Chronic inflammatory foci are exacerbated, which makes it possible for the inflammatory focus to resorb, for it would not have been capable of this prior to aggravation*. Lozinsky, just as Kirichinsky, explained the essence of the effect of natural and transformed physical factors on the basis of Ukhtomsky's dominant theory. They contended that relatively low-grade irritations of the patient's skin reinforce and intensify the dominant process to a certain degree, with the achieved effect of these factors dependent upon the intensity of the aggravation of the pathological process.

Obrosov (1969) concluded that the mechanism of action of physical factors is mainly reflexive, and in the long run is manifested in the activities of the endocrine and humoral systems. Thus, in the external use of mineral waters and application of muds, the leading reflex is that produced by the skin. In the internal application of mineral waters and the rectal method of mud therapy the humoral component of the mechanism of action is closely bound with the reflex component over the entire length of the gastrointestinal tract. Endocrine influences participate both in reflexive and humoral responses of the organism to the action of physical factors. The initial functional state of the organism creates a general background of reactivity. The specific physical and chemical properties are also very significant; they are reflected in the course of the protective-restorative processes, which determine the healing effect. The study of the physicochemical composition of many physical factors helped to define those specific properties in them which prove to be adequate to the biochemical and biophysical developments taking place in the organism at molecular and cellular levels in this or that pathology, i.e. appropriate to the pathogenetic links of the disease. Because of this, Obrosov claims, a positive therapeutic effect is achieved mainly by using small doses of this or that physical factor (of short duration, a small zone of exposure, moderate temperature or concentration of the physical agent).

By the 1950s-1960s the in-depth study of the mechanism of action of natural factors and recognition of the fact that the nervous sys-

* Lozinsky, *On the Mechanism of Action of Spa Treatment in Connection with Pavlov's Theory of Nervism* (in Russian), Nalchik, 1, 1953, 13-25.

tem, as a most sensitive formation, reacts even to the slightest external stimuli which are only of a signalling and informative nature for the response of the functional systems, plus the discovery of the neurohumoral influence of physical factors (Obrosov), resulted in the conception that the effect of physical factors on the organism should be less intensive in the majority of diseases. This principal change in therapeutic methods was also brought about by a change in the structure of morbidity, the wider use of new medicines (antibiotics, steroid hormones, cytostatics, etc.) and the resulting change in the reactivity of the organism.

It should be noted that the second stage in the study of the mechanism of action of natural medicinal factors is marked by the transition of scientists from purely empiric conceptions to the method of scientific experiment. Thus, comparison of obtained data with clinical observations, and the profound and comprehensive research of the physicochemical properties of natural medicinal factors were made possible.

Various criteria have now been established for determining the physicochemical characteristics of the main natural medicinal factors.

Mineral waters are complex multicomponent solutions in which substances exist in different states: ions, undissociated molecules, gases, colloid particles.

The fundamental ion composition of mineral waters is formed by the group of macrocomponents: cations Na^+, K^+, Ca^{2+}, Mg^{2+}, and anions HCO_3^-, Cl^-, SO_4^{2-}. The summarized content of these components (in g/l) usually constitutes the predominant part of general mineralization (M). The other, as a rule, insignificant part of the mineralization of mineral waters is represented by microcomponents which may be both in ion and in undissociated form. Some of the microcomponents which have a pronounced effect on the organism are set apart in a group of specific components (including Br, I, As, Fe, H_2SiO_3). The group of specific components of mineral waters also includes certain gases (CO_2, H_2S, Rn). The presence of these gases often determines the main therapeutic effect of the mineral water (carbonate, sulphide, radon waters). The index of alkalinity-acidity (pH) is of great importance in the therapeutic evaluation. According to the pH, it is possible to establish the ratio between certain interconnected chemical components, including H_2S and HS^-, CO_3^{2-} and HCO_3^-, Fe^{2+} and Fe^{3+}, H_2SiO_3 and $HSiO_3^-$.

Depending on the physicochemical properties of mineral waters and the character of their effect on the organism, Nevrayev and Ivanov (1964) differentiated mineral waters for external application used for baths, bathing in medical pools and other procedures, and mineral waters for internal use, for drinking.

Mineral waters for external application, as a rule, are distinguished

by the heightened content of dissolved substances (highly mineralized waters and brines, the latter are usually diluted for use), or they contain the above-mentioned specific components. Certain weakly mineralized thermal waters are also used for external application.

Mineral waters for drinking have a relatively low mineralization (2-12 g/l) and render a healing effect due to their ion composition or the presence of specific components (I, Br, Fe, As, organic substances, and others). If such components are present, waters with a mineralization of even less than 2 g/l may be regarded as mineral waters suitable for drinking. Potable mineral waters are divided into therapeutic dinner-table waters and therapeutic waters according to their degree of mineralization and intensity of effect on the organism. Therapeutic dinner-table waters have a mineralization of 2-8 g/l (with the exception of Essentuki No. 4 with a mineralization of 10 g/l). Potable therapeutic waters have a mineralization of 8-12 g/l, at times a higher mineralization (Lugela, for instance, 52 g/l). If the mineral waters contain specific components (As, Br, I, Fe, organic substances) their use as simply therapeutic or as therapeutic dinner-table waters is defined by the existing GOST standard, according to the concentration of the components named.

The following principles are adhered to in the balneological classification of mineral waters according to gaseous and ion composition. The name of the water includes only those gases which are contained in the water in amounts of no less than 10 per cent of all gases. In the naming of waters, according to ion composition only, those will be included which have no less than 20 equivalent per cent of anions and cations of the sum of equivalent per cent of each of the said groups of ions equal to 100 equivalent per cent. The components of gaseous and ion composition are listed in the names of the waters in order of their increasing content.

Kurlov's formula is used to designate the chemical composition and physical properties of mineral water; Kurlov introduced the formula in 1928 and it is still valid today. The specific components, including gases (in g/l, and for Rn in nanocurie l) are given at the beginning of the formula, then comes the mineralization (M) of the water (in g/l) and its ion composition (equivalent per cent) in the form of a conditional fraction with the anions in the numerator and the cations in the denominator. The pH and temperature values of the water are given at the end of the formula.

Since mineral waters for drinking may contain high concentrations of substances hazardous to health, the GOST standard establishes the permissible limits of such concentrations. The sanitary condition of mineral waters must also conform to strict requirements. The number of microorganism colonies in waters for internal and external application should not exceed 100 per 1 ml, the coli-titre

of potable mineral waters should be no less than 300, and for mineral waters for external use—no less than 100.

On the basis of the classification adopted in the USSR (Ivanov, Nevrayev, 1964), the following are the main balneological groups of waters: A. Waters, the therapeutic effect of which is induced by their ion composition and mineralization (i.e. waters lacking specific components or properties); B. Carbonate waters; C. Sulphide waters; D. Ferrous, arsenious, and 'polymetallic' waters (the latter with an increased content of ions in several metals such as Mn, Pb, Zn, and others); E. Bromine, iodobromine, and iodine waters; F. Radon (radioactive) waters; G. Siliceous thermal waters; H. Weakly mineralized waters with a high content of organic substances of the type of Naftusi water, and others.

Among carbonate waters twelve main groups are distinguished by their ion composition: hydrocarbonate calcium and magnesium-calcium, hydrocarbonate, calcium-magnesium-sodium, hydrocarbonate-sodium, sulphate-hydrocarbonate, magnesium-calcium, siliceous thermal, chloride-hydrocarbonate-sodium, chloride-hydrocarbonate sodium-calcium, chloride-hydrocarbonate, magnesium-calcium-sodium, chloride sodium (brine).

The above-mentioned groups are subdivided according to gaseous composition corresponding to the conditions of their formation (nitrogen, methane, carbon dioxide, at times—mixed, nitrogen-methane, and so forth).

According to the geological peculiarities of different regions of the world and the conditions under which subterranean mineral waters formed, several vast territories (provinces of mineral waters) are delimited, which are characterized by the presence of certain types of water (see Chapter 2).

Those waters most widely prescribed in spa treatment and under ordinary conditions are sulphide, carbonate, radon, thermal nitrogen siliceous, chloride sodium, iodobromine, and arsenious mineral waters.

The physiological and therapeutic effect produced by the external application of mineral waters on the organism is characterized both by a general non-specific effect and by certain specific properties inherent in various types of waters. They are determined by the physicochemical composition of the water and methods of its application as well as the nature of the course of the disease, its form and stage.

The general non-specific effects of mineral baths, medicinal muds, and climatotherapeutic procedures are seen in the different extent to which they give rise to haemodynamic, thermoregulatory, and neurovascular reactions. They change the tone and reactivity of skeletal muscles, the blood-filling of cutaneous vessels and peripheral resistance of capillary and precapillary network, which results in

the redistribution of blood. The frequency of respiration, intensity of urination, and so on are also altered.

The mechanism of action of mineral waters used for external application such as bathing in pools and baths consists of the combination of temperature, mechanical, and chemical stimuli. The skin is the first organ to receive these stimuli. It is richly supplied with blood vessels and nerve receptors and takes an active part in the processes of thermal exchange in the organism. A considerable difference in the heat capacity and heat conduction of water, of different chemical composition and concentrations, promotes an essential change in the heat emitting ability of the organism. Change in the level of peripheral reception is also affected by the fact that the indifferent temperature of the air is between 22-23 °C, while that of the water is 34-36 °C. The impact of the temperature stimulus depends on the difference between the temperatures of water and skin, on the length of the procedure, the place of application, and area to which the water is applied, and also on the condition of the body's reactivity and its individual peculiarities.

The influence of the mechanical factor in baths is determined by the pressure and movement of the liquid which covers the patient. This pressure is usually about 0.04-0.05 atm. Besides skin receptors, most sensitive to the mechanical factor in baths are veins and lymphatic vessels. When prescribing baths, the intensity of the mechanical factor may be varied, decreasing it by half-filled baths and increasing it by rubbing after the bath, or by vibrational baths.

The character of the specific influences of sulphide, radon, carbonate, and other mineral waters depends on their chemical composition. Some waters react predominantly on metabolic processes, others on the functions of the vegetative nervous system, the endocrine system, the higher regulating centres of the nervous system, stimulating the protective adaptive mechanisms.

The chemical components of mineral waters not only stimulate peripheral receptors. The gaseous substances (carbon dioxide, hydrogen sulphide, nitrogen, and others) penetrate the undamaged skin, respiratory tracts, and mucosa of the gastro-intestinal tract, affecting the receptors of vessels, internal organs, and through the blood, directly the nerve centres. The use of radioisotopic methods of research made it possible to establish the permeability of undamaged skin by ions of iodine, bromine, arsenic, etc. The stimuli of distant receptors play a significant role in the mechanism of action of mineral waters, whether applied internally or externally. Ivan Pavlov defined distant receptors to be the nerve instruments of vision, hearing, and smell, which are capable of analysing at a distance the action of different stimuli of the internal and external media.

For example, the colour and odour of the mineral water, as well as the conditions under which the balneoprocedure is conducted,

serve as stimuli. The response reactions of the organism to mineral waters do not depend only on the temperature, the physicochemical composition of the water, the concentration of chemical substances in it, and the number and length of procedures, but also on the initial functional state of the organism and its reactivity. By selecting appropriate methods for applying balneofactors depending on the disease and the initial functional state of the patient's organism, it becomes possible to achieve the desired effect on corresponding organs and systems. In some cases balneoprocedures may replace drugs, in other cases they may intensify the effect of drugs, and in still others they may create the needed background so that drug therapy will produce better results. One should bear in mind the balneoreaction in response to balneological treatment. There is a physiological balneoreaction when changes in the functional state of the organism remain within the limits of physiological fluctuations. There are also a pathological balneoreaction and a reaction causing exacerbation of the disease, which indicates that the measures being taken are inappropriate for the given organism. In the latter case the intensity of the treatment should be milder or balneotherapy should be temporarily discontinued.

The principal factor causing the specific effect of sulphide waters are the sulphides themselves which penetrate the inner medium of the organism either through the undamaged skin, or to a lesser extent, through the respiratory tracts. Free hydrogen sulphide and hydrosulphide ions pass through the skin. The higher the concentration of hydrogen sulphide in the water, the more of it gets into the organism. The length of the procedure and the skin surface area subject to treatment are important factors here.

Neimark (1946) applied the photocalorimetric method to define the amount of hydrogen sulphide entering the inner medium of the organism, and demonstrated that free hydrogen sulphide binds with the intermediate metabolic products, renders them harmless and evacuates from the body. Vorotilkin (1962) showed by experiment that the penetration of hydrogen sulphide into the organism leads to its increased content in the skin and internal organs. Gunin (1956) and Tikhonravov (1960) hold the view that the hydrogen sulphide which enters the organism during a bath rapidly oxidizes to sulphides, sulphur, and sulphates and becomes an inactive compound. Because of its chemical nature, hydrogen sulphide is a strong reducing agent and thus easily yields an electron, thereby becoming highly active chemically. In the cells of the organism it takes part in the redox reactions, first and foremost with the oxidized forms of proteins, enzymes, and other biological substrates. The number of free sulphhydryl groups grows, the physicochemical and biological activities of high-molecular proteins, enzymes, hormones of protein nature, as well as of low-molecular compounds, intensify. As a result, the

energy resources in tissue cells, including those of the heart muscle, are increased.

Nekhoroshev, Kaplun, Kopteva (1953). Nikitin et al. (1964) demonstrated how free hydrogen sulphide passes through the skin to the blood, circulates in a bound and free state, and in pharmacologically active doses influences the receptors of vessels, various organs and tissues, intensifying metabolic processes. It is known that the cells use sulphur for building proteins, cystine, cysteine, and glutathione, which participate in redox processes.

As a result of conjugate redox reactions of hydrogen sulphide with proteins and enzymes, the oxidizing processes increase while reduction processes decrease. In the meantime, certain correlation exists between the metabolism of catecholamines and formative materials. It is general knowledge that the biosynthesis of adrenaline occurs during the process of interaction of several enzymatic systems participating in the processes of oxidation, decarboxylation, methylation, and others. The latter reaction takes place with the participation of sulphur-containing amino acid.

Sulphur is a component of the cellular structure of articulations and also of the cartilage and mucin of the synovial fluid. Sulphatides become involved in nerve cells and their processes; they are also found in tendinous sheaths, muscles and other components of joints.

Kopteva (1971) established that hydrogen sulphide makes its way not only into the blood, but also into the cerebrospinal fluid, exerting a direct influence on cellular structures of the central and peripheral nervous system. These data testify that sulphide baths produce a dual reaction on the nervous system: on the one hand, they influence the peripheral exteroceptors (mechanically, thermally and biochemically), and on the other hand, when free hydrogen sulphide is present in the blood, the sulphide baths exert a direct influence on the interoceptors and nerve cells. Meanwhile, the tonus and reactivity of the nervous system change, and there is an increase in neurovascular processes in the synovial membranes, the trophics, and in the secretion of cells producing the synovial fluid which is supplied to the epiphyseal cartilage.

It should be emphasized that hydrogen sulphide exerts a specific influence over nerve elements and skin capillaries, and makes the skin turn red. Some authors thought that reddening of the skin occurs as a result of a local reflexive vascular reaction, while others presumed that reddening of the skin develops as a result of the reflexive paresis of vasoconstrictors and the development of haemostasis in the capillaries. On the basis of clinical experiments, Nesterov (1939) arrived at the conclusion that sulphide baths induce a complex reflexive process which forms the basis for the development of active hyperaemia, ischaemia, and the normalization of capillary circulation. Stepun (1937) considers reddening of the skin under the influence

of sulphide baths to be the result of the appearance in the skin of biologically active histamine and serotonin which cause the dilatation of the capillary and precapillary network. Mast cells play a major role in the development of this process; they become actively involved in metabolic-trophic and reactive changes occurring in the skin. Gruzdev (1968) proved that sulphide baths first excite the nerve receptors of the skin, and then block them, in other words, make them incapable of perceiving new stimuli. An increased concentration of hydrogen sulphide or a rise in water temperature may again intensify the process, exciting the nerve receptors of the skin and mucous membranes.

Kaplun (1958) demonstrated experimentally that tenths of a fraction of the gamma-hydrogen sulphide injected into the carotid artery cause a clear-cut pharmacological effect: arterial pressure changes, cardiac activity slows down, the activity of the respiratory centre increases and so does the frequency of respiration. These changes are linked with the heightened sensitivity of the chemoreceptors of the sinocarotid zone. Korolev (1971) showed that when hydrogen sulphide penetrates the cell, it influences the membrane structures, particularly the membranes of the mitochondria. The cytochemical tests made for succinodehydrogenase showed that morphological changes in the granules of the cell nucleus are evidence of increased permeability of mitochondrial membranes. The results of electron microscopy revealed that locally widened spaces between the inner and outer membranes of the mitochondria also indicate a change in the permeability of these structures. The discovered changes in the mitochondria, in all probability, depend on the condition of the submicroscopic and molecular particles in which the processes of respiration and oxidizing phosphorylation are accomplished, and this testifies to the intensification of the oxidation processes in the cell. Korolev also found that under the influence of hydrogen sulphide the space between the endothelial and hepatic cell becomes wider, and the number of microvilli increases.

In sulphide baths of low concentrations (100 mg/l) hydrogen sulphide increases the metabolic processes; in high concentrations (300-400 mg/l), the processes of respiration and phosphorylation are separated, which obviously results in the change of the morphological structure of mitochondria, and the metabolic processes are thus depressed.

The principal active factor of carbonate waters is carbon dioxide which affects the skin as well as the inner medium of the organism when it penetrates the skin, and the mucous membranes of the respiratory tracts and the gastro-intestinal tract. Penetrating the skin, CO_2 causes hyperaemia of the cutaneous vessels (reaction of reddening) and the redistribution of blood in the body. Carbonate baths do not place high demands on the work of the heart, which explains

their wide application in diseases of the circulatory system. By facilitating to heighten CO_2 in the blood, carbonate baths exert a stimulating effect on the central nervous system, intensifying the function of external respiration, and improving haemodynamics and gaseous exchange in the tissues. Carbonate baths have a pronounced stimulating effect on the tactile-nervous apparatus of the skin, which is followed by blocking. This blocking action, however, is not quite as clear-cut as that seen in the application of sulphide baths.

Radon baths are far more potent than carbonate baths in blocking the sensitivity of nerve ending and in accelerating metabolic processes in the cell.

In his experiments on animals, Khudoteplov demonstrated that as soon as one hour after radioactive irradiation (particularly thorium emanation dressing), the local temperature of the skin rises and the activity of cholinesterase intensifies. Three days after irradiation the content of DNA and RNA in the skin of rats continues to be elevated. These local changes in the cells remained in the aftereffect period, too.

When the patient takes radon baths or procedures, a depot forms in his skin of radon and its daughter products, which in disintegrating irradiate for the most part this same tissue. This irradiation is from 30 to 40 times the average dose received by other organs and tissues. Since radon spreads unequally, different organs and tissues are also irradiated to various degrees. The peroxides forming in the process exert a pronounced biological effect on the cells and tissues of the organism, and it is likely that even the biostructures in the cells are directly affected by irradiation.

Under the influence of radioactive irradiation during radon baths local biochemical and morphological changes occur which lead to what might be termed as a 'pathological focus' of stimulation in which the levels of histamine and serotonin content fluctuate accompanied by an increase of the general content of acidic mucopolysaccharides (glycosaminoglycans). This increase develops mainly at the expense of chondroitinsulphates. The content of heparin increases somewhat, while the level of hyaluronic acids remains practically the same. Just as in the use of sulphide baths, radon baths of low concentrations enhance cellular metabolism, whereas in high concentrations, when the radioactive irradiation of the cell intensifies, the process of intracellular respiration is suppressed and, consequently, metabolism is depressed.

Shemyi-Zade's (1971) research revealed that radon escapes into the atmosphere together with the soil gases, or emanates from the surface of rocks. It is also true that the concentration of radon in the atmosphere depends on the condition of the Earth's magnetic field. In the author's opinion, additional amounts of radon escape to the atmosphere with the intensified activity of the Earth's magnetic

field, which grows with the increased number of flares on the sun. Due to multiple magnetostrictive compression, radon seems to be 'squeezed out' of the microcracks of rocks and grains of minerals (the concentration of radon in the pores of rock is 10^6 to 10^7 times higher than in the atmosphere).

Thus, in the period of high solar activity and enhanced action of the Earth's magnetic field, the radon content in the air, particularly in the air of radon health resorts, increases and, consequently, the dosage of radon baths should be slightly decreased.

The mechanism of action of nitrogen siliceous thermal waters consists in the sedative influence produced by the mechanical and thermal effect of gas bubbles on the skin receptors. Moreover, nitrogen baths render an analgesic and desensitizing effect.

Besides the general reflexive influence through the skin, chloride sodium baths also produce a localized effect, giving rise to pronounced functional shifts in the receptor apparatus of the skin, its cellular elements and vessels. Zolnikova and Nefedov (1970) demonstrated that chloride sodium baths stimulate the receptor apparatus of the skin, intensify bielectric pulsation in the nerve fibres, and cause a heightened reaction to tactile stimuli.

The morphological studies of Gersamiya and Soldatov (1969) testify that under the influence of the fifth chloride sodium bath (concentration 20 g/l) the nerve fibres thicken, their impregnation decreases and tiny beads bulge out on the small nerve branches. No less marked changes occur in the skin epidermis: the horny and malpighian layers thicken as a result of intercellular oedema.

These waters have a regulating influence on the functioning of the central nervous system and cause a certain immunological reconstruction in the organism, as well as definite changes in the metabolic processes.

The ions of iodine contained in iodobromine waters normalize the impaired functions of the thyroid gland and the hypophyseal-adrenal system.

On penetrating the organism, the iodine ions are absorbed by the thyroid gland, activating its function. They also participate in the synthesis of the gland's hormones, thus helping to normalize the body's basic metabolism. This is accompanied by the increased consumption of oxygen by the tissues and the increased coefficient of its use.

Bromine baths normalize the processes of nervous regulation, intensifying the processes of inhibition. As compared to sulphide baths, iodobromine baths have a milder, sparing effect on the cardiovascular system which allows for their wider application for elderly patients.

The principal action of arsenious waters on the organism consists in the biologically active microelement arsenic, which settles on

the skin and then penetrates into the inner medium of the organism. Arsenic participates in enzymatic reactions of tissue respiration and influences metabolism in cells and tissues. The effect of arsenic on the cell has a number of peculiarities: an unequal dilatation of intercristal spaces; the space between the outer and inner membranes (external chamber of mitochondrion) expands in some places; the functional activity of mitochondria changes. Besides, there is a marked disorientation of cristae in relation to the longitudinal axis of some mitochondria, the level of glycogen in muscle fibres decreases. These intracellular processes are evidence of the intensifying activity of metabolic processes.

Balneotherapy induces intraneural and interneuron processes in the cerebral cortex, correcting corticosubcortical relationships. The influence of each type of mineral water, however, has its own specific features. The experiments performed by Zolnikova, Nefedov and Sitel (1970) by means of electrodes implanted in the brains of animals showed that the very first chloride-sodium, sulphide or carbonate bath already causes changes in the bioelectric activity of the hypothalamus even under normal conditions.

It has been established that the hypothalamus reaction, especially of its frontal and lateral parts, differs with each type of mineral water and the number of baths. The first four chloride sodium baths cause higher bioelectric activity of the subcortical structures, while subsequent balneoprocedures fail to induce a further increase.

Sulphide baths intensify inhibition processes. Towards the fourth sulphide bath inhibition gradually mounts, and by the seventh it becomes sharply pronounced. After the seventh bath inhibition processes in the hypothalamus abate, and by the twelfth bath they reach the level of the fifth procedure. A comparison between the character and degree of excitability of peripheral reception (see Gruzdev's experiments cited above) and the change in the bioelectrical activity level of the hypothalamus shows the correlation between these processes.

Mud therapy is one of the major methods in comprehensive spa treatment.

Medicinal muds constitute a homogeneous thinly-dispersed plastic mass composed of water, and mineral and organic substances which possess certain thermal properties (high heat capacity and heat-retaining ability, and low heat conduction). According to their source which determines their properties and composition, muds are subdivided into certain genetic types: peat mires, sapropels, sulphide silt sludges, clayey slurries, and volcanic muds. Sulphide silt sludges, sapropels, and peats are most widely used in mud therapy. About 500 deposits of therapeutic muds have been studied in varying degrees in the USSR, a fact reflected in 'Catalogue of Therapeutic Mud Deposits in the USSR (1968)'.

Medicinal peat mires consist mainly of decayed organic substances and the vegetative residues of swamps. There are small amounts of mineral substances in peats. According to the degree of mineralization of slimes, peats are subdivided into freshwater and mineralized sediments.

In highly acidic peats mineralization may reach 250 g/l or more. Sapropels, which are silt deposits, are mainly of organic composition with a small admixture of mineral substances, forming, for the most part, in freshwater reservoirs as a result of the microbiological disintegration of algae and other vegetative, as well as animal remnants.

According to the species composition of organic remnants and the nature of their mineral substances, sapropels are subdivided into algae and zoogenic, humus and peat, clayey and lime sediments. Sulphide silt sludges are subdivided into organomineral silt deposits of different reservoirs with a considerable predomination of mineral components containing ferrum biocompounds. According to sulphide contents, these sludges are subdivided into weak-sulphide, sulphide, and strong-sulphide muds, in the mineralization of their mud solutions they are distinguished as low-, medium- and highly mineralized muds. In accordance with the conditions of their formation, sulphide muds are distinguished as lake and spring, continental, seashore, and marine silts.

Clayey slurries are thinly-dispersed mineral sediments of reservoirs with a small content of organic substances.

Volcanic muds are semiliquid clayey formations created in the process of rock disintegration. As a rule, they are characterized by hydrocarbonate-chloride sodium ion composition and a 10-20 g/l mineralization of their mud solution. Volcanic muds often contain increased concentrations of bromine, iodine and boron.

The therapeutic effect of muds, just as of mineral waters, is the result of a combination of thermal, mechanical, and chemical factors. The degree to which this effect is pronounced depends not only on the functional state of the patient's organism, but on the physicochemical properties of different types of muds. The nature of the entire organism's reactions and of different organs and systems of the body must be further studied because the information to date is still somewhat fragmentary.

The thermal effects of various types of therapeutic muds on the organism are not the same. The heat conduction of mud is determined by the chemical substances contained in it, by the ratio of organic and inorganic compounds, and so on. The heat conduction of sulphide silt sludges is nearly twice that of peats, which is explained by the large content of mineral substances in sulphide silt sludges. Because of this, mud therapy conducted at the same temperature with sulphide silt sludge is harder for the organism than a procedure with

peat or sapropel. Under the influence of the thermal factor, more or less intensive dilatation of the vessels is observed at the place of mud application, depending on mud temperature, as well as acceleration of blood flow in them, temperature rise in the surrounding tissues, normalization of permeability, and acceleration of metabolic processes. In heating muds of different compositions to the same temperature, the effect is different, which depends on pH and the degree of their mineralization. Muds with a higher mineralization and a sharp acidic index are conducive to a more pronounced normalization of excitability of the neuromuscular apparatus and skin thermoreceptors; they also stimulate certain enzymatic and neurohumoral processes to a greater extent.

The mechanical factor in mud therapy is not as important as that in mineral baths treatment, but it should be taken into account both in external applications and in the treatment of internal organs. The layer of mud in skin applications should be no less than 4-5 cm thick, and up to 400 g of mud may be used for vaginal and rectal mud packs. It is believed that a fair pressure on the underlying tissues is conducive to spreading heat in them to a greater depth.

The chemical effect in the use of medicinal muds is determined by their component organic and inorganic compounds and biologically active substances, trace elements, etc. The nature of physiological reactions developing in mud therapy to a great extent depends on the composition of the muds. Thus, in an experiment aimed at the comparative study of the effect of sulphide silt and peat mires, it was found that procedures with sulphide sludge stimulated the functions of the medullary layer of the adrenals, while peat mires depressed them. According to Zolnikova et al. (1968), these changes were more pronounced in experimental hypothyreosis. In experimental hepatitis, muds of higher mineralization caused a more pronounced stimulation of ascorbic acid metabolism in the organism and normalization of the hepatic function than muds of lesser mineralization. Inorganic chemical components of the muds are mainly absorbed by the skin, stimulating the skin receptors and vessels. Particles of organic substances (humic acid, amine bases, hydrogen sulphide, nitric substances, etc.) penetrate the inner medium of the body through undamaged skin and may influence directly organs and tissues. An important role in the healing effect of muds is played by their biologically active organic substances, such as enzymes, vitamins, mediator-type substances like histamine, acetylcholine, as well as hormone-like substances like folliculin and other oestrogenic hormones. This explains the high efficacy of mud therapy at a certain stage (chronic and subacute) of inflammatory gynaecological diseases.

The morphological changes that take place under the effect of mud therapy are most manifest in the cells of the skin. The reaction of acidic (pH 1.8) peat taken from the Sapozhkovsky deposits causes

(according to Soldatov, 1969) thinning of the horny and clear layers, and thickening of the granular layer of the skin. Vacuolization of the cells of the growth layer also occurs. Changes in the dermis take place resembling inflammatory infiltration: there is an increase in the number of lymphocytes, histocytes and eosinophils. Various components of the mud, such as iron, appear among cells of the dermis.

Among the organic components of medicinal muds antioxidants have been found which are capable of regulating enzymatic processes in tissues, and cellular metabolism. Mud therapy enhances the activity of many enzymes (catalase, oxydase, cholinesterase, etc.), thus accelerating redox processes, improving tissue respiration and gas exchange. The antioxidizing effect of mud therapy explains the positive influence this treatment exerts on tissue regeneration. The course of mud therapy treatment normalizes the immunological reactivity of the organism, reduces the susceptibility to allergy, and brings the indices of non-specific immunity back to normal. The most obvious effect of mud therapy is observed in its action on the local inflammatory process. By causing hyperaemia of the tissues, improving trophics and the function of blood circulation, courses of mud applications promote the resolution of the pathological products of inflammation. The products of protein disintegration seep into the blood, producing the effect of 'autoproteinotherapy'. This augments the defensive and adaptive potentials of the organism, activates the hypothalamo-hypophyseal-adrenal system, and stimulates the function of the sympathico-adrenal system. Just as under the influence of balneoprocedures, mud therapy increases the number of functioning capillaries, the release of blood from depots, accelerates the blood flow, and boosts the volume of blood circulating in the body.

Aeroheliothalassotherapy and aeroionotherapy are climatotherapeutic factors which also play a major role in combined physical therapy.

Such natural parameters as the magnitude of atmospheric pressure, the intensity of electric and magnetic fields, radioactivity, wind velocity, humidity, the character of solar radiation, the quantity and ratio of positive and negative ions of air, aerosols of air saturated with marine salts, etc. contribute to the effect produced by climatic factors.

The methods of climatotherapy serve as biologically grounded means for stimulating the vital activities of the organism. They are natural stimulants for the human body under the influence of which various physiological regulatory mechanisms evolved (e.g. neurohumoral mechanisms of regulation, which produce histamine in response to the action of solar radiation, the system of physical and chemical thermoregulation, and others).

In conducting climatotherapeutic procedures, aerotherapy, for one, the thermoadaptive mechanisms are trained which constitutes the basis for hardening and for strengthening the links between the organism and its environment. As a result of regular aerotherapy, the thermoasymmetry of various areas of skin is reduced, reaction to cold temperatures is decreased, metabolic processes, including redox processes, are normalized and stimulated. Therefore, aerotherapy may be regarded as a method of natural oxygen therapy. Climatotherapy is a physical method conducive to the restoration of the disturbed functions of the cardiovascular, respiratory, and several other systems which are of great importance in the process of rehabilitation. A major role in the responsive reactions of the organism is played by precisely those organs and systems at which the predominant effect of this or that climatic factor is aimed. In aerotherapy, the effect is aimed mainly at the system of thermoregulation, in heliotherapy, it is aimed at the sympathetico-adrenal system, and so on. Climatotherapy is a pathogenetic method of treatment. At the initial stages of hypertensive disease, for instance, it is conducive to reducing arterial pressure and enhancing the contractile function of the myocardium, at the early stages of atherosclerosis it helps to normalize lipid metabolism, and so forth.

When prescribing climatic treatment at spas it is most essential to bear in mind that in persons suffering from certain chronic diseases (of the cardiovascular system, joints, respiratory organs, and others) an abrupt change of climate, particularly at the early stages of acclimatization, may give rise to many pathological reactions with the predomination of a cerebral, cardiac, vegetative-vascular, arthralgic, or some other symptom complex, depending on the specific features of the main or concomitant disease and the peculiarities of the climate to which the patient is unaccustomed. Climatic reactions may be acute in the form of stress, or disadaptation meteoneurosis (according to Danishevsky). In such cases, treatment consists of the therapeutic measures usually resorted to in exacerbation of the disease.

In distinction from the above-mentioned natural therapeutic means, physicotherapeutic factors include certain phenomena of nature, which have been transformed by man into different types of energy: electric current, electric and magnetic fields and their combinations, the artificial solar radiation spectrum, mechanical vibrations, artificial aeroionization, and others.

To prescribe an appropriate treatment including the most effective combinations of natural factors, one must not only know the factors' physicochemical properties, but must also have a definite idea of how the given factor affects biochemical, physiological, and other processes in a given disease. In some instances these factors may prove to be adequate, if their dosages correspond to the level of general

reactivity of the organism and favourably influence the course of the disease. In other cases, when the doses of the given factor are changed, i.e. there is a change in the method of its application, or if the method remains the same but the reactivity of the most important functional systems is changed (either reduced, heightened or disturbed) because the organism is sick, these factors may cause a negative effect. Such an evaluation of the natural factor's effect, however, reflects the general idea of connection between the organism and the active therapeutic means. A deeper study of the initial mechanism of action of these factors in some diseases illuminated the different character of changes in the organism at various levels and in various systems and organs.

The healing effect of the physical factor begins from the moment it comes into contact with the patient. In some cases this contact is accomplished via the direct action of mineral waters, medicinal muds, or climatic factors on the cellular and neurovascular elements of the skin and mucous membranes. In other cases the components of these factors influence the cellular elements of the respiratory tracts, and the neurovascular and glandular apparatus of the gastrointestinal tract; in still others various components trigger corresponding reactions in distant analysers.

The components of mineral waters and therapeutic muds contact with numerous nerve endings (receptors), with skin cells, and with mucous membranes. Moreover, the specific components of these factors (their gases, colour and odour), as mentioned above, influence distant analysers. Complex reactions (at the molecular level) occur in the protein structures of these formations among the ions, cations and biologically active substances. These reactions stimulate impulses spreading along the centripetal nerve fibres to the spinal cord and brain.

According to the feedback principle, the nerve impulses received by the cerebral cortex, the subcortical formations, and spinal segments are drawn primarily to those stagnant foci of excitation which had originated as a result of the pathologically fixed link between the diseased organ and the cells of the brain. The impulses seem to block the existing foci of excitation, causing them to subside, thus rupturing the vicious circle which is created in corticovisceral relations as the disease advances.

It should be borne in mind that under the influence of various healing natural agents the above-mentioned anatomofunctional formations in patients do not become involved in equal measure, and the biochemical transformations of energy of the applied components are not accomplished at the same speed. There are many reasons for this: on the one hand, this depends on the functional state of different organs and systems, and on the other hand, on the physicochemi-

cal structure of therapeutic natural factors and the methods of their application.

In a disease the regulating functions of the central nervous and adaptive systems —the sympatho-adrenal, hypothalamo-hypophyseal-adrenal systems—are disturbed; the functional disproportions between them develop, the enzymatic, hormonal and metabolic processes become distorted; deficiencies of various trace elements and vitamins intensify; the relations of the ion and cation composition change not only in the humoral medium of the organism, but in the cellular structures too. These and many other disorders connected with the character and nature of the disease depend on the condition of the protective and adaptive mechanisms of the neurohumoral and other systems, which often determine the clinical manifestations of the course of the given disease.

In different pathologies, the cortical structures participating in the organism's physiological defense are functionally changed to varying degrees. In diseases of infectious-allergic or inflammatory nature (rheumocarditis, rheumatoid arthritis, pneumonia, hepatitis, nephritis, and others) along with disorders of the cerebral cortex function, there are disturbances in the activity of the hypophyseal-adrenal system and the immunity system, in the hormonal link of the sympatho-adrenal system, and others. In dystrophic diseases of the heart, vessels, stomach, joints, spinal cord, skeletal musculature, and liver there is a decrease in the function of the hypophyseal-thyroid system. The adaptive-trophic function of the sympathetic nervous system is suppressed, and the functions of the capillary and precapillary networks are disturbed, as well as the entire system of microcirculation.

It is an established fact that in a patient suffering from ischaemia of the heart disorders of reflexive and neurohumoral processes, which develop as a result of various harmful reactions, are different from the disorders which occur in patients with rheumatism or rheumatoid arthritis. These mechanisms also differ in patients suffering from gastric or duodenal ulcers, deforming osteoarthrosis, intervertebral osteochondrosis, etc. Thus, recurrent rheumocarditis which is a severe disease leads to myocardial cardiosclerosis, diseases of the heart, and circulatory insufficiency.

Rheumocarditis is accompanied by a decrease in the function of the hypothalamo-hypophyseal-adrenal system and a heightening of the hormonal link of the sympatho-adrenal system, and also by disorders of the immune system. These changes are conducive to the activation of the inflammatory process, they increase the permeability of cellular membranes, enhance the exudative component, and intensify auto-immune reactions. All this causes dysregulation of neurohumoral and metabolic processes. The development of chain auto-immune reactions destroys the structure of connective tissue

including that of the myocardium, and damages the cells of the heart muscle. This is why the content of the antinuclear, and anticardial antibodies increases in the internal medium of the organism, free sialic acids appear in the blood serum, the erythrocyte sedimentation rate (ESR) increases, and the content of C-reactive protein, histamine, serotonin, etc. increases too.

β-haemolytic streptococcus of group A (in foci of infection in the tonsils, in carious teeth, nasal sinuses) participates in the formation of rheumocarditis, and as a result of its toxic effect on various cells and tissues, such antibodies appear in the humoral medium of the organism as antistreptolysin-O, antistreptohyaluronidase. The leukocyte and lymphocyte counts also increase, just as the content of accumulated glycogen in them. The accumulation of glycogen in segmentonuclear leukocytes and particularly in lymphocytes is considered to be a defensive reaction because in such cases glycogen serves as energy material necessary for phagocytosis. The functions of the enzymatic systems are altered to a great extent in rheumocarditis, particularly in the foci of infection, steroid metabolism is disturbed, the transport functions which ensure these processes are suppressed, the evacuation of metabolites from the body is slowed down. In rheumocarditis clinical evidence reveals that along with pain in the heart, dyspnoea, perspiration, general weakness, and reduction of working capacity there are changes in the bioelectrical activity of the myocardium, rhythm of cardiac activity, particularly if the rheumatic process affects different elements of the conducting system of the myocardium; this leads to cardiac failure.

Those reflexive-vascular mechanisms which control coronary circulation play a significant role in the deterioration of cardiac activity. Their change leads to the decelerating of metabolic processes in the myocardium and disorders in intracardiac haemodynamics. These alterations aggravate the rheumatic process.

Sulphide or radon baths are prescribed at this stage of the pathological process as part of combined treatment which includes drug therapy, climatotherapeutic, and balneological procedures (courses of sulphide, radon or carbonate baths). In such patients, as a rule, pains in the heart and joints are alleviated, inflammatory phenomena abate, primarily in the myocardium, its blood supply, intracardiac haemodynamics and redox processes in the muscle cells of the heart are improved, and the force of heart contractions is strengthened. The results of special tests show that the indices of the electrocardiogram return to normal, the intensity level of infectious and cellular immunity is reduced, just as the level of C-reactive protein, and the content of sialic acids in blood serum. The ESR is also decelerated.

Clinical and experimental data support the assumption that the functions of the hypothalamo-hypophyseal-adrenal, immune, and

sympatho-adrenal systems improve under the influence of physical factors acting on the subcortical vegetative centres.

Radon baths activate the function of the immune system, enhance the tonus and reactivity of the vegetative nervous system: α-radiation stimulates the function of the thymus which is of major importance in immunity processes. The migration of lymphocytes is intensified, the level of properdin and lysozyme rises, as well as of the peroxydase activity of leukocytes. These processes, to a great extent, decrease auto-immune processes and increase the non-specific resistance of the organism. This is accompanied by the improved synthesis of steroid hormones which activate α- and β-adrenoreceptors and render a permissive effect (a slight increase in the level of these hormones is sufficient for stimulating the activity of α- and β-adrenoreceptors and improving trophic processes, particularly in the myocardium). Simultaneously, in connection with the normalization of the regulation of the hormonal link in the sympatho-adrenal system, the discharge of adrenaline into the humoral medium is reduced, redox processes in the myocardium are improved, and so on.

The mechanism of action of radon baths and their therapeutic effect depend on the concentration of radon and the activity of rheumatic process. If rheumocarditis develops with a low activity of the process, 10 procedures of radon baths with a concentration of 40 nanocurie/l lasting 7 minutes every other day will alleviate the clinical manifestations of the disease (less pain in the heart, fewer heart contractions, lower body temperature, less perspiration and weakness). Special tests show normalization of cardiac activity, water-salt metabolism, improved steroid metabolism, reduction in the activity of auto-immune processes reduces destruction of collagenic structure of connective tissue, etc. If rheumocarditis develops with a medium activity of the inflammatory process, radon baths of the same concentration lead to exacerbation of the disease and even to its progression due to lability and increased reactivity of the above-mentioned systems. This is attended by a lower synthesis of steroids or the release of free hormones, the increase of the binding ability of transcortin, a higher titre of specific immunity, as well as of immunoglobulins. Moreover, the level of C-reactive protein and sialic acids rises, and the ESR increases. All this signals the activation of rheumocarditis and calls for the introduction of new elements of the therapeutic complex: drugs, high-frequency electromagnetic oscillations, etc. The action of high- and ultrahigh-frequency electromagnetic oscillations suppresses the activity of inflammatory process by influencing the metabolic processes.

The direct action of electromagnetic oscillations on the adrenals, sympathetic lumbar ganglia, the region of the liver, abdominal aorta and spleen, solar plexus, as well as on the region of the heart

(from the side of the spinal column), causes profound changes in the organism. These changes ensure through subcortical vegetative centres and neurohumoral shifts the increased function of adaptive-trophic systems, which changes the level of catecholamines, biologically active substances, strengthens their bonds with blood proteins bringing about conformation of the protein structures proper. Proskurova's (1970-1975) research showed that in rheumocarditis patients substantial changes take place in relations between various fractions of steroid hormones under the influence of inductothermy.

The detailed study of these questions by Tsarfis, Frenkel, Proskurova, Davydova, Kostrova, Fiveiskaya, and Mayorova (1970-1976) established that in patients suffering from rheumocarditis, rheumatoid arthritis, and systemic sclerodermia, the synthesis of steroid hormones intensifies to varying degrees under the influence of inductothermy. The increased synthesis of hormones in the adrenal cortex is the result of stereochemical enzymatic transformations of cholesterol to steroid hormones. Vitamin C is also of vital importance in this process. In collagenous diseases not only the increased synthesis of steroid hormones acquires great significance in the above-mentioned changes, but also the increase of the sum total, bound and free steroids. The splitting of the protein-steroid complex is induced by the above-mentioned high-frequency electromagnetic oscillations, as a result of which free steroids are released. It is precisely the free steroids which cause the thickening of cellular membrane, the suppression of auto-immune processes, the change in steroid metabolism, the decrease in cell proliferation processes, etc. In other words, it is the steroids which exert an anti-inflammatory influence.

The injection of hormonal agents like prednisolone, dexamethasone and triamcinolone in patients with various inflammatory diseases is known as substitution therapy. These drugs compensate for the lack of endogenous hormones and at the same time suppress the cortical function of the patient's adrenals. Such treatment makes patients dependent on hormones. Under the influence of high-frequency electromagnetic oscillations the improvement is noted: pains in the heart disappear, dyspnoea and perspiration decrease, muscular strength increases, and psychoemotional stability increases. The data of laboratory tests provide evidence that the hormonal link of the sympatho-adrenal system improves, just as in the long run the formative and energy processes in the cells. It should be emphasized that in distinction from rheumocarditis, in rheumatoid arthritis high-frequency electromagnetic oscillations are also applied locally, for example, on affected knee and shoulder joints. In addition to the above-mentioned processes, the blood supply to the tissues of the joint intensifies, as a result of which the function of the cells lining the inner coat of the joint improves. The metabolic processes are accelerated as well as the transport of hormones to the damaged

cells (synoviocytes). The process of destroying the synovial membrane is suppressed, and the intensity of the inflammatory process in the joint is reduced.

The application of balneotherapy in chronic ischaemia of the heart, deforming osteoarthrosis, gastric and duodenal ulcers induces substantial changes in the development of these diseases.

The common feature in the pathogenesis of the listed diseases is the disturbance of the adaptive-trophic function of the sympathetic nervous system which, as Orbeli put it, 'controls' the trophic processes in the organism. In ischaemic heart disease, however, of no less significance than the disturbance of the trophics of the myocardium in the clinical course of the disease are psychoemotional disorders which aggravate the neurovascular dysregulation of circulation in the myocardium right down to the microcirculatory bed. This has a negative effect on the transportation of oxygen, hormones, trace elements, formative and energy materials to the dystrophically changed muscle cells, and on the evacuation of metabolites from them. These changes, in turn, aggravate functional disorders of the heart muscle, particularly its ability to contract.

The chemical energy of adenosine triphosphate (ATP) is not utilized by the heart muscle (as it had been presumed earlier) directly for accomplishing mechanical work, but is first transformed into free energy of the concentration electrochemical converter. In this case the muscle is analogous to an electrochemical fuel element. The 'fuel' for it is ATP and other biochemical compounds, while the principal result of its work is the appearance of a potential difference in the membrane structures. The reserves of ATP in the muscles are not great. The ions would soon be expended if not for reduction which may take place anaerobically, i.e. without oxygen, or aerobically, i.e. with the participation of oxygen. The resynthesis of ATP is accomplished by means of the creatine phosphate contained in the muscles, which forms the basis of the creatine-kinase reaction and the glycolysis reaction (the anaerobic oxidation of carbohydrates to pyruvic or lactic acids). The creatine-kinase reaction is swift and effective: one molecule of ATP is reduced for every molecule of creatine phosphate. The reserves of creatine phosphate, however, are also sparse. It contains many carbohydrates, and therefore the main part of the reduced ATP falls to the share of the glycolysis reaction. The glycolysis reaction yields very little energy, while the lactic acid which forms affects the acidity of the medium and causes a number of unfavourable changes.

The aerobic reaction is the most effective way to resynthesize ATP. In aerobic oxidation of glucose to carbon dioxide and water, the yield of ATP is 12 times greater than in the glycolysis reaction. Moreover, the respiratory restoration of ATP is distinguished by an abundance of substances which can participate in the oxidation

processes, and by the harmlessness to the organism of the end products of metabolism (carbon dioxide and water). If the respiratory system fully supplies the muscles with oxygen during work, these processes are rapidly resumed. If a pathological process arises in the heart muscle, in ischaemia of the heart, for instance, there is not enough oxygen, and the organism suffers from an oxygen deficiency in which case it mobilizes anaerobic processes. In the opinion of Fedorov (1977), the biological storage of potential difference performs 'the function of a reserve battery in an electrochemical generator', which allows the system to produce a lot of power within a short period of time.

The mechanical movement of the muscle is the movement of polyions. Engelhardt thinks that apart from the above-mentioned functions, ATP also plays the part of a'lubricator', a plasticizer. Figuratively speaking, ATP molecules serve as rollers along which the protein threads slide. It should be remembered that the sarcoplasmic reticulum is threaded by tiny fibres of myofibrils (0.5-2 μm thick) which consist of several hundreds of protofibrils, or a skein, formed by bundles of protein molecules. Excitation of the membrane spreads along tubules to the cavities of the reticulum, where the concentration of calcium ions is about 10 000 times greater than in the sarcoplasm. The nerve pulse or the pulse running through the conducting heart system excites the coat of the fibre. The ions of calcium seep into spaces between protofibrils, activating the hydrolysis of ATP molecules. Energy is produced in the process of this reaction, which is transformed (according to the principle mentioned) into mechanical work. In pathology of the myocardium, the intensity of these processes is disturbed and the mechanical effort wanes. Disorders in the contractile activity of the myocardium, in turn, lead to intracardiac haemodynamic disturbances and disorders in the external respiratory functions, which have a telling effect on the vital activity of the organism.

In hypokinesia connected with ischaemia of the heart or with other diseases of the cardiopulmonary system, and also when a person is bedridden for an extended period, the entire complex system of gas exchange performs under a small load. This decreases the elasticity of acini walls, reducing the intensity of gas exchange between them and capillaries, which results in the deterioration of redox processes in the cells not only of the myocardium, but of the entire organism. The nerve cells of the cerebral cortex are particularly sensitive to the oxygen deficiency. Therefore, procedures for patients suffering from chronic ischaemia of the heart, which stimulate the function of external and tissue respiration (carbonate, sulphide or radon baths in combination with other physical therapeutic factors, and above all staying in the fresh air) exert a favourable influence over the course of the disease. Climatotherapeutic procedures with

dosaged motor activity in terrain cure are also beneficial in such cases.

The adaptive-trophic function of the sympathetic nervous system is enhanced under the influence of baths named. Confirmation of this is found in the considerable increase in the content of adrenaline, noradrenaline, dopamine, and dopa in the diurnal urine. The delivery of these catecholamines to the myocardium also intensifies the redox processes in the latter and promotes the increase of biopotential difference in its muscle cells, facilitating the mechanical work of the heart. On the other hand, the influence of radon, particularly of carbonate baths, on the vagus nerve causes heart contractions to slow down: this increases the length of the diastole of the heart ventricles, and the minute volume of blood, creating favourable conditions for work of the heart. Psychoprophylactic measures are also of major importance. The training of the cardiovascular and respiratory systems and the strengthening of the muscular system are also conducive to enhancing metabolic processes and improving the transportation of metabolites to the excretory organs and systems (kidneys, respiratory system, skin area, mucosa of the gastrointestinal tract).

In distinction from chronic ischaemia of the heart, in deforming osteoarthrosis the action of natural physical factors is aimed at the inhibition of dystrophy and activation of trophic and secretory processes in synovial and cartilaginous cells since the greatest changes occur in these cells in these diseases. Tests have shown that the onset of deforming arthrosis is also triggered by a decrease in the adaptive-trophic function of the sympathetic nervous system (distortion of the form and function mainly of large joints as a result of nutritional deficiencies in tissues in and outside the joint's muscular sheath).

In this disease, dystrophic changes take place in the basic elements of the locomotor system which, because of disorders in the delicate mechanisms controlling movements due to nervous disturbances and impaired nutrition of the synovial membrane and epiphyseal cartilage covering the articular surface of bones, result in severe deformations. As a consequence of resulting osseous 'projections' and disintegration of the cellular elements of the joint which acquire 'antigenic' properties, an aseptic inflammation of the synovial membrane develops, which leads to the appearance of constant, at times very severe pain, limiting the patients mobility.

This disease occurs at a mature age, primarily in people suffering from an affection of the nervous system. This testifies to the leading role which the nervous system plays in the development of the dystrophic process in the synovial membrane and its cellular elements (synoviocytes). The reduced blood supply to this membrane and the appearance of its fatty degeneration are closely related to the depressed

adaptive-trophic function of those sympathic nerve fibres which supply the synovial membrane as well as the fibrous capsule, the muscular sheath, and the ligamentous apparatus of the joint. The determination of catecholamines and, particularly of noradrenaline and dopamine, will reveal their great loss, moreover, parallels have been established between the degrees of this loss and the stage of the disease. According to the data of clinical, X-ray and morphological studies, the greater the loss of catecholamines, the more the adaptive-trophic function of the sympathetic nervous system is disturbed, and the more pronounced is the dystrophic process in the joints. These changes are evidence of the noticeable obliteration of capillaries, the death of the surface layers of synovial cells, the decrease of the secretory function of cells remaining in the deep layers of the membrane, the reduced process of the outflow of the liquid portion of blood into intercellular spaces and, therefore, the reduced amount of synovial fluid in the cavity of the joint. At the same time, with the advance of the process in the synovial membrane, the foci of sclerosis and hyalinosis increase, while the number of blood vessels, including arterioles, capillaries, precapillaries (cytophotometric data) considerably decreases, the processes of microcirculation are disturbed, and a great number of metabolites accumulates. The decrease or disappearance of synovial fluid in the cavity of the joint deprives the cartilage of nutrition. The joint deforms, secondary synovitis develops as a result of constant microtrauma. and there is a sharp disturbance of the locomotor function. A similar process develops in the intervertebral disks. Cracks appear in their fibrous capsule through which the pulpy nucleus of the disk frequently seeps through partly or fully. A chronic traumatism of the nerve roots occurs, as well as of the cartilage of intervertebral articulations. A secondary inflammatory process develops in the nervous cord and roots, which is clinically manifested by sharp pain and disorders in motor and sensory functions. Arthrosis of the costovertebral articulations develops in conjunction with this and, as a result, the motor function of the entire osteomuscular system is disturbed.

The tone and reactivity of the nervous system in patients suffering from deforming osteoarthrosis and intervertebral osteochondrosis rise under the influence of radon, sulphide, chloride sodium, and other mineral baths. Neuroreflexive and humoral processes are activated, while local trophic processes are to a great extent improved. These baths applied directly to the affected joints help to intensify local trophic processes due to local (short) reflexes which are linked via spinal segments at the level of the affected joint. The improvement of local blood and lymph circulation in the tissues of the joint or of intervertebral articulation leads to the proliferation of capillaries into the avascular zones of the synovial membrane and fibrous capsule, the appearance of synoviocy es where they had

not existed formerly, and the replacement of fibrous tissue by more differentiated cells. These changes develop against the background of central, reflexive, and neurohumoral shifts which take place during treatment. The intensification of all metabolic processes in the cells of synovia, which is seen towards the end of the course of treatment with physical factors such as sulphide baths, results in the restoration of disturbed trophics in the synovia and the epiphyseal cartilage.

Biochemical tests have proved that meanwhile the level of catecholamines in the diurnal urine, particularly of noradrenaline and dopamine, increases, the number of lysosomal enzymes in the blood serum, just as the total number and different reactions of proteoglycan-like compounds, decreases. Hydrogen sulphide, as a strong reducer, penetrates the cells of the synovial membrane of the joint, enhances their respiratory activity, and intensifies the activity of the oxidizing enzymes of the tricarbonic acid cycle, etc. Moreover, correlation is established between the state of redox processes, exchange of catecholamines, and formative processes aimed at restoring the structure of the cell. A major role in these interrelations also belongs to the inclusion of different components of sulphide waters, particularly of sulphhydril groups and trace elements, into the cell structure, the chain of biochemical transformations of the cytoplasm of cellular organelles and their enzymatic systems. These processes promote the acceleration of vital activity of the synovial membrane cells, the increase of their secretory function, and regeneration. Intensification of cells regeneration and their secretory activity promotes the normalization of metabolism in the epiphyseal cartilage covering the articular surface of the bone, and prevents advancing of the disease.

Similar changes occur under the influence of a course of radon baths. Histomorphological and cytophotometric studies conducted by Tsarfis and Arutyunov (1973-1976) confirmed that trophics of the synovia and cartilage improved greatly as a result of radon therapy. New zones of vascularization appeared, pyroninophilia of the cells of the synovial membrane formed in places where it had not existed formerly, new zones of synoviocytes to the extent of microvilli appeared, and the amount of synovial fluid increased. All this has a favourable effect on the trophics of chondrocytes and the connective-tissue reticulum of cartilaginous cells. Zones I and II of the chondrocytes are rehabilitated and the former thickness of the cartilage is retained. This results in the improvement of osmotic and diffusion processes of cellular membranes, particularly for oxygen, and trophics and metabolism in the cells of the cartilage are also improved. This is especially important in regard to chondrocytes because in arthrosis their structure and function are sharply disturbed.

In deforming osteoarthrosis, trophic processes improve under the

influence of radon baths as a result of intensified local blood circulation as well as of the direct effect of α-radiation on the synoviocytes enzymes (the increase of their regeneration), and development of other complex processes. However, in gastric or duodenal ulcers, radon baths of external or internal application cause considerable changes of tone and reactivity of the sympathetic nervous system controlling the trophic function of the organism, including the mucous membrane of the stomach and duodenum. As a result of these complex changes, the nutrition of the mucosa cells is improved, its ability for regeneration increases and the aggressiveness of the secretory cells of the principal digestive glands, primarily of the glandular cells producing hydrochloric acid, is weakened. The defect in the mucous membrane is filled in with cellular and connective-tissue elements. The inflammatory infiltrate around the defect of the mucosa is reduced or disappears, pains and dyspeptic phenomena (heartburn, eructation, meteorism, etc.) abate, sleep improves, irritability and perspiration decrease.

Long years of observation have shown that one and the same mineral baths applied by the same method may have a positive effect in various diseases and, on the contrary, mineral baths of different composition may also produce a positive therapeutic effect in the same disease.

How can such a universal effect of natural factors in different diseases be explained? The crux of the matter is that there are common features in the pathogenesis of many diseases (such as gastric and duodenal ulcers, myocardiodystrophy, deforming osteoarthrosis) though they may be different in aetiology, clinical picture and prognosis. To be more precise, these common features are dystrophic changes in different tissues (in the first instance in the stomach, in the second instance in the myocardium, and in the third, in the synovial membrane and epiphyseal cartilage of the joint). In all these diseases the adaptive-trophic function of the sympathetic nervous system is disturbed, inducing the obliteration of the finest vessels, and the blood supply to the organs and tissues decreases. As a result, the neurotrophic processes slow down, cellular metabolism is impaired, the activity of lysosomal enzymes accelerates, the level of the hormonal link of the sympatho-adrenal system drops, and a large number of metabolites accumulate in the humoral medium. These diseases take on a chronic course and are apt to recur. Such different nosological forms as rheumatic affection of the heart, rheumatoid arthritis, and similar diseases also have pathogenetic features in common: the character of the affection of the vegetative nervous system to the extent of its central formations in the subcortical region; functional disorders in the hypothalamo-hypophyseal-adrenal, sympatho-adrenal and immunity systems. In these diseases the collagenic structures of the connective tissue are destroyed and

sialic acids are released, C-reactive protein appears, and the ESR accelerates. Depending on the severity of the inflammatory process, three degrees of its activity are distinguished. Clinical findings demonstrate that the application to patients with the diseases mentioned of radon baths or their combination with radon water exerts a therapeutic effect as a result of the influence of physical factors on the main pathogenetic chains.

In patients suffering from deforming osteoarthrosis, gastric and duodenal ulcers or myocardiodystrophy, radon baths of low concentration (40 nanocurie/l) cause an increase of the adaptive-trophic function of the sympathetic nervous system, which improves blood supply and the trophics of the affected organs, the mucosa, submucosa, and muscular sheath of the stomach, the superficial and subsynovial layers of the membrane of the joint, endo- and myocardium, etc. These processes, in turn, are conducive to the improvement of blood and lymph microcirculation, the development of collateral blood circulation, the increased transportation of oxygen, carbohydrates, fats and proteins, vitamins, trace elements, and hormones to the cellular structures, and the evacuation from them of various metabolites. Radioactive emanation and the products of disintegration of radioactive elements render a direct influence on intracellular metabolic and secretory processes. They also promote the intensification of the vital activity of organs and tissues, change the permeability of cell membranes, suppress the activity of lysosomal enzymes, and reduce the number of metabolites. Under the influence of internal use of radon water there is an improvement in viscerovisceral reflexive activity, of the secretory, motor and evacuative functions of the principal digestive glands, the splitting of nutritious products, their absorption and transportation in providing the organism with formative and energy materials. The use of radon baths of high concentrations (120 and 200 nanocurie/l) has proved to be less favourable than baths of low concentrations, particularly for patients with a predominance of the inflammatory component, because under their influence balneopathological reactions and exacerbations of a disease develop more readily.

In rheumocarditis or rheumatoid arthritis with a minimum activity of the process, radon baths first of all bring about substantial changes in the immunological reactivity which plays a major role in the course of the inflammatory process. There is an increase in the immunological non-specific reactivity which is very important in stabilizing the resistance of the organism to deleterious environmental influences. There is a noticeable drop in the level of immunoglobulins, especially of G, A and M, indicating the suppression of auto-immune processes. The intensity of the specific humoral and cellular immunity is reduced, and the sensitivity of α- and β-adrenoreceptors to catecholamines is increased. These changes result in

weakening the exudative component of inflammation, a lesser destructive process and an improvement of cellular metabolism, as well as lesser vegetovascular disorders. Special tests revealed, however, that in medium activity of the inflammatory process, radon baths of the same concentration decrease the synthesis of oxycorticosteroids, lower the level of total, protein-bound and particularly free 11-oxycorticosteroids, increase the number of biogenic amines (serotonin, histamine), restrict the binding of serotonin with thrombocytes, and hardly change the level of adrenaline and noradrenaline.

According to Frenkel's (1976) experimental data, several radon baths as applied to animals with adjuvant arthritis failed to decrease adrenaline and its fractions in the myocardium, or to restore the correlation between proteins of the heart and 'total' adrenaline. The insufficient restoration of the sympathetic effect of catecholamines in the heart is accompanied by a reduction in glucocorticoid activity. After treatment with radon baths, the content of corticosteroids in the adrenals and liver remains basically unchanged. Radon baths are conducive (as compared to non-radon baths) to a slight increase of free (functionally inactive) glucocorticoids. After treatment with radon baths there is a decrease of total and protein-bound 11-oxycorticosteroids, as well as of the binding ability of transcortin; the concentration of free biologically active glucocorticoids in the blood plasma does not change. This evidences that the inflammatory process is slightly alleviated. Similar data has been obtained from patients suffering from rheumatoid arthritis and rheumocarditis. On the basis of this information, we may draw the conclusion that as a result of appropriately prescribed treatment with radon baths, substantial changes take place in the immunological reactivity: the titre of auto-antibodies goes down, the number of immunocompetent cells decreases, the levels of properdin and lysozyme rise.

Similar changes have been observed as a result of treatment with sulphide, iodobromine, and other mineral baths. During treatment, the specific effect of each type of mineral water becomes manifest. The character of these specific traits also depends on different forms and stages of the pathological process. Carbonate waters, for instance, are effective after recovery from rheumocarditis and formed mitral disease, particularly when the disease is at the stage of remission. They are not prescribed in rheumatoid arthritis, however, even when the disease is in a similar stage. The vagotropic effect develops under the influence of carbonate waters: the length of the diastole increases, coronary circulation improves, intracardiac cardiohaemodynamics intensifies, etc. The same baths in rheumatoid arthritis alter the functions of the sympatho-adrenal and immune systems, although the changes are not sufficient to produce a healing effect. Under the influence of these baths, the syndrome of hypocorticoidism does not disappear in patients, infiltrative and dystrophic processes are not

reduced, and locomotor disorders and visceral shifts do not abate. Exacerbation of the subsided rheumatoid process occurs more frequently. At the same time the prescription of sulphide or iodobromine baths for these patients in the same phase of the process brings about positive changes, because they affect those pathogenetic mechanisms which participate in the onset and clinical manifestations of rheumatoid arthritis. Under the influence of sulphide baths, the hypocorticoidism syndrome disappears, the exudative and proliferative component of inflammation abates, trophic processes improve, the locomotor function and muscle tonus are heightened, etc.

It should be borne in mind that the disease may be exacerbated under the influence of these baths if they are applied during an active rheumatoid process, even if the disease is minimally active. This is why in patients suffering from rheumocarditis, rheumatoid arthritis, and other inflammatory diseases, the combination of radon baths with the application of high- and superhigh-frequency electromagnetic oscillations produces a far greater therapeutic effect than that of radon or sulphide baths alone. Such combinations may be used in treating patients not only with a minimal but with a medium-level activity of the inflammatory process. The mechanism of the healing action of such a complex consists in the fact that electromagnetic oscillations against the background of radon baths give rise, besides the changes mentioned, to substantial shifts in neurohumoral regulation, an increased synthesis of corticosteroids, suppression of autoimmune processes, diminished permeability of cellular membranes, improvement of cell metabolism, and to the mitigation of the inflammatory process.

The described clinical and experimental studies testify to the fact that changes in the patient's organism caused by the application of various natural factors do not occur suddenly by means of one link, but through a system of links with cortical and subcortical formations, adaptive-trophic systems as well as local cellular and subcellular structures. The healing effect depends on the functional condition of a number of physiological systems, the form and phase of the pathological process, and also on the physicochemical properties of the natural factor. Both the increase of cell metabolism, and the intensification of metabolic processes take place against the background of the above-mentioned neuroreflexive, hormonal, and enzymatic processes, and as a result of the direct influence of different components of mineral waters and therapeutic muds in the process of their absorption by cells. This, in turn, sets a new level for the functioning of different cells, tissues and organs, shifts the metabolic balance, and enhances the energy resources of the organism.

The acceleration of metabolic processes under the influence of these changes sets a new level for the energy potential: formative and energy substances are stored in various tissue depots and a change

takes place in the reactivity of cell structures of whole organs and systems. It is precisely these changes which produce a remedial effect. These changes lead to the increase of immune and protective forces and promote the activity of adaptive neurohumoral systems, which in turn preserves the accomplished therapeutic effect for some time. If the pathological process has only progressed to such an extent that the natural factor can restore disturbed functions, the therapeutic effect is prolonged or the patient virtually recovers. If dystrophic changes in the tissues develop or the reactive systems are severely damaged leading to organic changes, natural factors promote the restoration of disturbed functions by means of compensatory mechanisms. In every disease only the compensatory mechanisms characteristic of that disease develop. Exhaustion of the compensatory capacities of the organism because of unfavourable environmental factors (such as overstress, poor working and living conditions, psychoemotional, and other negative experiences) lead to the disturbance of compensation and hence to the exacerbation of the disease. The properly timed application of a repeated course of treatment with natural factors can prevent the exhaustion of the compensatory capacities of the organism and prolong the therapeutic effect. If no positive healing effect is achieved under the influence of natural factors, it is necessary to combine them with drugs or special substitution therapy by infusing steroid hormones, insulin, thyreoidine, and other medicines to the patient or to resort to surgery.

In various diseases different mechanisms of natural and transformed physical factors which lead to changes in the organism's reactivity have been discovered. This is crucial for elaborating the principles of the combined treatment of patients with various clinical forms and stages of the most common diseases.

Chapter 6. The Use of Physical Factors in the Combined Treatment of Ischaemic Heart Disease

it is currently a well known fact that the number of patients suffering from ischaemic heart disease is constantly increasing in economically developed countries. This is caused, first of all, by the technicalization of production. In the process of work, vibration and noise put stress on the cardiovascular and nervous systems. In the second place, it has been established that risk factors (alcohol, smoking, increased body weight, arterial hypertension) and particularly the combination of a number of factors, of which there are now more than fifty, give rise not only to myocardial infarction, but to the exacerbation of ischaemic heart disease. Thirdly, there is an increased number of patients due to the low efficacy of treating chronic ischaemic heart disease and due to the fact that younger people now suffer from myocardial infarction.

6.1 Myocardial Infarction: Treatment and Rehabilitation

Epidemiological research reveals that mortality from sudden myocardial infarction is very high. Chazov (1971) noted that most people die from acute coronary deficiency within the first few hours and days, i.e. as early as during prehospital stage, of the disease. Among the general population, for example, of one of Moscow districts the mortality rate from myocardial infarction in the first 28 days of the disease was registered between 35.1-37.5 per cent; moreover, 80.2 per cent of these patients died in the first 24 hours after the attack. Mazur (1975) emphasizes that 68.7 to 70.7 per cent of all patients die before they reach the hospital. Within the first hour after a myocardial infarction only 2.5 per cent of all patients are hospitalized, and only 45 per cent are hospitalized within the first 24 hours. It is also a fact that the mortality rate for persons between the ages of 30-39 who suffer a myocardial infarction is 30 times higher than for those in the same age bracket who suffer from other diseases. U.S. specialists have estimated that an efficient system of resuscitation in the United States could save at least 250 000 lives a year. Chazov

and Ruda (1973) reported that successful resuscitation of patients with myocardial infarction, even with cardiac fibrillation, revives one out of two victims.

Mazur (1975) pointed out that the data of epidemiological research provides evidence that many medical establishments have been successful in treating and rehabilitating patients with myocardial infarction. After a year of drug therapy and exercises up to 80 per cent of the able-bodied patients return to their jobs. At the same time, up to 75 per cent of the patients who had suffered an acute myocardial infarction become capable of working after 5-6 months of treatment with physical factors. But these patients, just as those who had been treated with drugs, must undergo repeated courses of spa treatment and rehabilitation.

The social implications of the problem discussed are thus quite obvious.

Despite the progress of recent years made in the diagnosis and treatment of patients with myocardial infarction, the disease is still formidable and fraught with dire consequences. These consequences occur as a result of the fact that the pain shock and sudden circulatory disorder which accompany infarction cause substantial changes in the central nervous system. The disturbance of blood supply to the brain, the cortical cells of which are extremely sensitive to hypoxia, and the development of excessive reflexive stimulation of the hypothalamic region result in the dysfunctioning of the main control systems and the deterioration of circulation in the heart itself. Necrosis of a certain portion of the heart muscle may therefore develop as a result of the sudden occlusion of coronary vessels or of their severe spasms. Substantial enzymatic, hormonal and hypoxic changes occur against the background of different necrotizing portions of the myocardium.

Myocardial infarctions are distinguished as being small- or large-focal, uncomplicated or complicated, according to the extent and size of necrotic areas. The most frequent clinical manifestations of these complications are shock, disorders of cardiac rhythm, and pneumonia.

Small-focal myocardial infarction is characterized by its favourable course and outcome (prognosis), whereas with large-focal infarction complications occur very often. Undoubtedly, the diagnosis of focal infarction presents much difficulty. It is particularly difficult to differentiate small-focal infarction in focal dystrophy of the heart muscle.

Besides the characteristics mentioned, the typical large-focal infarction of the heart muscle is characterized by the fact that the pain syndrome is attended by vegetative disorders (perspiration, weakness, palpitation, intestinal disorders), by the appearance of an increased number of leukocytes, the increased activity of enzymes

in the blood, the increase of the ESR, the appearance of C-reactive protein, and increased number of hexoses, and so on. There are cases, however, when patients, particularly elderly people, experience no pain in the development of this disease. This phenomenon is often explained by the fact that collateral blood circulation is well developed in the heart muscle of such people; this is why hypoxia is weakly pronounced and there is very little pain.

Pain in myocardial infarction may not be typically localized, i.e. occur not in the heart, but in the stomach, for instance, the right hypochondrium where the liver is located, or the pain may simulate various diseases of abdominal organs. In view of this, regular electrocardiograms acquire a special diagnostic significance. They help the physician to divulge the nature of a given disease.

Myocardial infarction does not take place with equal intensity in young and elderly people, particularly in patients with a hypertensive disease who suffer from persistent and lengthy attacks of hypertension.

It should be remembered that myocardial infarction occurring in persons suffering from chronic ischaemic heart disease, or hypertensive disease, undoubtedly aggravates these diseases and often leads to the development of cardiac failure. An inadequate contraction capacity of the myocardium and a decrease in the cardiac output are registered in such cases in almost every patient. This decreases the supply of formative and energy materials and oxygen to organs and tissues. As a result of intensified hypoxia, the permeability of cell membranes is disturbed and there are disorders in ion equilibrium. The accumulation of insufficiently oxidized metabolic products leads to acidosis which aggravates the process and violates the most important function of the myocardium, namely, supplying blood to organs and tissues, and, first and foremost, to the myocardium itself.

A disturbance of the calcium content in the cell lowers the contractive capacity of muscle fibres, which also depends on a reduced accumulation of noradrenaline in the cells. The reduction of noradrenaline synthesis is detected by disorders in the adaptive-trophic function of the sympathetic nervous system, the nerve endings of which are incapable of ensuring this process sufficiently. The combination of all these disorders, i.e. the reduced amount of noradrenaline and electrolytes, weakens the process of energy production.

The diminished contractile capacity of the hypertrophied heart decelerates the minute volume of the cardiac output. The expulsion of blood by the heart depends on the length of the muscle fibre when the heart muscle relaxes, i.e. during diastole. It is obvious that the change in the contractile capacity of the heart muscle is revealed by haemodynamic indices. Above all else, the tempo of contraction slows down and the length of contraction periods is reduced.

In patients suffering from myocardial infarction, substantial changes take place in the phasic structure of the heart cycle, i.e. in the complex of changes of heart contractions during systole; moreover, these changes last for quite a long time. The time factor for the adaptation of the heart to new conditions acquires profound importance particularly when the matter concerns the restoration of these processes.

The objective criteria for determining these processes are the indices shown by spiroergometry, which are very slowly restored and characterize the relationships between the bronchopulmonary and cardiovascular systems.

In the development of cardiac insufficiency, particularly in ischaemia of the myocardium, the process of eliminating metabolic disorders during diastole cannot keep up with the biochemical changes which occur during systole. This must never be forgotten, particularly when choosing the therapeutic factor and its method of application. True, the compensatory devices of the organism, primarily tachycardia, to a certain measure, help to supply the tissues with oxygen. Moreover, under these conditions, peripheral resistance increases reflexively at the expense of a change in the tone of capillaries. Nevertheless, once cardiac failure has developed, the changes continue to grow in different inclusions of the muscle cell, primarily in the mitochondria, sarcosomes, the lamellar complex and in other intracellular organelles. These biochemical and morphological disorders, to a certain degree, form the basis for the disturbance of heart contractions and are revealed by general cardiohaemodynamic changes, particularly by the development of hypodynamia and by compensatory hypertrophy of other parts of the heart. Cardiac failure develops more often in elderly persons, particularly after repeated myocardial infarctions and the subsequent development of ischaemic cardiosclerosis.

It should also be remembered that after an acute infarction various disorders of rhythm may occur, primarily, extrasystolia, paroxysmal tachycardia and disorders of conductivity. These disorders are mainly the result of metabolic disturbances, particularly of electrolyte metabolism, which are induced by acute hypoxia of myocytes.

It may be stated that myocardial infarction is a serious disease with a complex pathological process which calls for the close attention of the physician capable of comprehending the process, making a timely diagnosis and rendering skilled aid both at the developmental stage and during the disease, and also in the period of convalescence. We shall not dwell on the means with which patients are treated at these stages, but merely note a high therapeutic and particularly rehabilitative effect which is achieved if the physical factors are included in the complex of these measures in good time.

Just 8 to 10 years ago the opinion prevailed that patients who had

suffered a myocardial infarction should be treated only with drugs, dieting, and a regimen of limited movement: in the first 2 to 3 weeks after the infarction complete bedrest was prescribed. The methods of physical therapy were considered to be contraindications, because such patients allegedly needed complete rest. Meanwhile, versatile numerous investigations and clinical observations conducted over the last 5-6 years at the Institute of Physiotherapy and Spa Treatment under the USSR Ministry of Public Health (Sorokina et al.) established that physical factors may be successfully applied during the early stage of the development of myocardial infarction. The question boiled down to what clinical manifestations were to be considered and what methods should be used in applying these factors.

As soon as 2 to 5 weeks after the beginning of acute myocardial infarction, it is expedient to include physical training exercises and low-frequency pulse current in the therapeutic complex; in another 2 weeks, two- or four-cell carbonate or radon baths, sleep induced by electricity and dosaged motor loads. These physical factors may be combined with drug therapy or used without drugs, depending on the degree of focal changes in the myocardium, on the extent to which atherosclerotic cardiosclerosis has developed, on the presence of coronary reserves, as well as on the degree of hypodynamia or training of patients. Under the influence of carbonate baths bradycardia develops, the cardiac output increases as a result of the increased force of heart contractions, neurotic manifestations of the disease are mitigated (reduced pain in the region of the heart, the normalization of sleep at night, less irritability, tearfulness, etc.), the training fitness of patients and their endurance of physical loads increase, and so on. After a month of this treatment, patients with postinfarction atherosclerotic cardiosclerosis are immediately sent to a local sanatorium for the first stage of rehabilitation. The main idea behind rehabilitative measures at this stage is: (1) to intensify the methods of applying carbonate waters by increasing the amount of water (first diluted and later undiluted baths), by lowering the temperature of water to 34-35°C, and by administering the baths not every other day, but two days running with a day interim; (2) to increase motor activity (increased length and rate of walks); (3) to prescribe air baths, sleep in the open air; (4) to increase the length of night sleep, etc.

These rehabilitative measures make the patients feel much better: pain in the region of the heart disappears, dyspnoea is reduced, motor activity increases. Patients begin to walk long distances (up to 6-8 kilometres), their working capacity is noticeably boosted (the load on a bicycle ergometer is raised from 150 to 300-400 kgm) accompanied by a stable pulse and the patients feeling well. At the end of the course there is an improvement in the basic indices characterizing intracardiac haemodynamics, the cardiac output grows

and the bioelectric activity of the heart increases, cholesterol and δ-lipoprotein levels go down while the level of catecholamines (particularly of noradrenaline and dopamine) rises. The amount of hexoses and sialic acids is reduced, ballistocardiographic and rheocardiographic indices are improved, which is a signal of the improved blood-filling of the myocardium, contractile ability of the heart muscle and its bioelectric potential, and the disappearance of myocardial ischaemia.

All this provides grounds to presume that physical factors in the treatment of these patients have acquired substantial medicobiological and sociological significance, all the more so since 75 per cent of all the patients who suffered myocardial infarction and did not experience any complications were able after 4-5 months of the development of the disease to return to their professional occupations.

Clinical observations revealed, however, that these patients were unable to work for extended periods of time after the first stage of rehabilitation. To prevent the possibility of pain attack and the development of ischaemia of the myocardium as well as of the increased metabolism of the myocardium, these patients should move on to the second stage of rehabilitation. True, there are signs of disturbance of coronary circulation in 25 per cent of patients when they travel to the health resort or upon arrival. This happens particularly if the patients failed to adhere to the recommendations of their physician to use coronary dilative agents, if they carried even small loads, or failed to observe their diet, etc. With the correct choice of appropriate physical loads, however, appropriate dosages of mineral baths, physiotherapeutic procedures, and strict observance of dosaged walking in terrain cure (rising up a slope) within a few days patients adapt to local conditions and begin to feel well. Daily walks, saturation of the organism with oxygen, carbonate or hydrogen sulphide baths of low concentration every other day, air baths, a rational daily schedule of activity (alternation of loads with rest, sleep with wakeful activity, the compensation of energy expenditures, increased training, and reduction of hypodynamic disorders) improve the general well-being of patients, intensify coronary circulation, and stimulate their working capacity. After the second stage of rehabilitation all this promotes an increase in the work time, the elimination of any possibility of renewed episodes of angina pectoris, of the aggravation of neurotic processes, prevents insomnia and the increase of irritability. It is therefore desirable for such patients to be treated with drugs and physiotherapy at their local clinic in the intervals between spa treatment.

It is most important for the patients to observe a work regimen in the line of secondary prophylaxis, and to adhere to the schedule prescribed by their physician. They should neither drink nor smoke and avoid conflict situations. They should avoid quarrels and not

get involved in psycho-emotional troubles. They should not overstrain themselves physically, keep to a chosen diet without overeating, and pursue a moderate life-style. This is extremely important for improving circulation (first and foremost in the myocardium). to prevent attacks of angina pectoris and hypertensive crises. and thus a renewal of myocardial infarction. It is essential to restore and strengthen their health.

6.2 Chronic Ischaemic Heart Disease: Treatment and Rehabilitation

The developmental mechanism of ischaemic heart disease is extraordinarily complex and has not been fully studied. This disease may occur as a consequence of oxygen lack in the atmosphere. a spasm of coronary vessels, metabolic shifts, or neurohumoral disorders. The principal cause of myocardial ischaemia, of course, is atherosclerosis of the coronary vessels.

In atherosclerosis of the coronary arteries severe disorders disrupt the supply of blood to the heart muscle. Some changes occur when this process affects a small arterial branch, while other changes develop as a result of the atherosclerotic process occluding first one, and then another large coronary arteries. In the first case, the lack of blood supply is compensated for by collateral blood circulation and the myocardium virtually does not suffer an oxygen deficiency. In the second case, on the contrary, there are manifestations of severe hypoxia sharply reflected in the heart's contractile function.

Clinical tests and special research have established that living and working conditions, overstress of the nervous system, disorders of neuro-endocrine regulation, and a faulty diet (abundant, fatty foodstuffs, overeating, the drinking of alcoholic beverages) often lead to the development of atherosclerosis.

Statistics show that atherosclerosis is more rarely encountered in countries where the population consumes less animal fats (the People's Republic of China, Italy, Bulgaria).

During World War II the incidence of atherosclerosis fell off sharply in the Scandinavian countries in connection with the shortage of fats in food of their population. This disease most often begins as a result of the disturbance of lipid and fat metabolism. The β-lipoproteins damage the vascular wall, particularly its inner lining, and focal indurations appear in it. Cholesterol accumulates in these indurations, in the long run forming plaques of various sizes. This narrows the lumen of arteries and slows down the blood flow. A prominent role in the development of atherosclerosis is played by disorders in the function of the liver. Under normal conditions not only the synthesis of cholesterolesters and phospholipids takes place in the liver, but their splitting, as well as the oxidation of fatty

acids and other substances. When the function of the liver weakens, however, all these substances are not fully neutralized. They remain in the blood in ever increasing amounts, settling from time to time on the walls of the changed vessels and taking part in the formation of the aforesaid plaques.

The development of the atherosclerotic process in the coronary arteries results in myocardial ischaemia, a considerable reduction in the supply of oxygen to the heart muscle, an intensified process of thrombus formation, whereby the thrombi may obstruct the lumen of the vessel. These disorders have a negative effect on the contraction ability of the heart muscle and lead to disturbances of intracardial circulation.

Vascular atherosclerosis often develops simultaneously with the hypertensive disease. Purely for this reason, the two affections are not regarded separately but as one disease, which in some cases manifests itself as hypertension and in others as atherosclerosis.

The causes for the origin and mechanisms of the development of atherosclerosis and ischaemic heart disease constitute a serious problem, a problem being tackled by WHO which coordinates the joint research conducted in such countries as Bulgaria, Hungary, GDR, USSR, Czechoslovakia, Sweden, and several others. Special attention is given to the developmental mechanism of atherosclerosis with the aim of disclosing the role played by trace elements in food, man's physical activity, his position at a high altitude above sea level, and disorders in lipid metabolism.

Certain data has been accumulated in recent years confirming the assumption that trace elements are of major importance in the development of atherosclerosis, hypertensive disease and myocardial infarction. In autopsies of victims of these diseases, their body tissues reveal changes in the concentration of trace elements (copper, magnesium, molybdenum, selenium), as well as in the ratio between the concentrations of cadmium and zinc. In healthy people, such changes are quite insignificant. Observations established a noticeable connection between the concentration of trace elements in the soil and in human tissues and the spread of the above said diseases in different areas of the world. In probing the essence of these processes, modern research methods have made it possible to evaluate the importance of ecological ties and reveal those peculiarities of the geographical region which might induce the development of different heart diseases.

The study and assessment of various components of the environment which influence the origin and spread of many cardiovascular diseases are based on the comprehensive analysis of such components, divulging the nature of their effect on the functional condition of the vital organs and systems of the organism. It has been established that such factors as trace elements, the mineral composition of

drinking water, foodstuffs, and vitamins have a telling effect on the development and course of many diseases, including ischaemic heart disease.

Geological structures with a low content of trace elements and relatively soft water emerging to the surface are found in seven countries including Scotland, Sweden, Finland and Denmark. There is a high incidence of cardiovascular diseases in these countries. The spread of these diseases has been registered on territories consisting of very young strata of the Quaternary Period, which formed less than a million years ago. Such deposits are also found in Belgium, Hungary, Northern Italy, Romania and Eastern Yugoslavia. The incidence of cardiovascular diseases in these regions is higher than in the countries adjoining them. A similar picture is seen in the United States, particularly in the State of Georgia.

Scientists presume that a drop in the calcium level in a person's blood may be a pathogenic link in the developmental mechanism of the harmful influence of soft water on the function of the heart and vessels. Moreover, as valuable components of the enzyme systems of the myocardium, calcium and magnesium regulate the electrolyte equilibrium. Consequently, when the mineral salts contained in drinking water and soil upset this equilibrium in the myocardium, its stability in the tissues of the heart may be affected. It should always be borne in mind that emotional and muscular loads are accompanied by a greater activity of the sympatho-adrenal system, an increased synthesis of catecholamines and their more intensified flow into the humoral medium of the myocardium and other organs of the human body.

Stimulation of the cerebral cortex under emotional stress is transmitted to the hypothalamus where norepinephrine is released from the nerve cells. By activating noradrenergic elements, norepinephrine stimulates sympathetic centres and thus intensifies the activity of the sympatho-adrenal system. This leads to the increased discharge of adrenaline from the medullary layer of the adrenals. The blood becomes enriched with adrenaline which through the haemato-encephalic barrier penetrates into certain portions of the limbico-reticular system and the hypothalamus. The adrenergic elements of the central nervous system are activated, while the serotinergic and cholinergic elements of the brain are simultaneously stimulated. Their increased activity triggers the formation of the releasing factor which, flowing into the hypophysis, is conducive to the entrance of ACTH into the blood. This hormone in the adrenal cortex intensifies the synthesis of corticosteroids. They easily penetrate the hypothalamus and, according to the feedback law, slow down the formation of the releasing factor. Consequently, their content in the blood begins to decrease. Under long-term and life-hazardous stress, however, corticosteroids bind with a peculiar blood protein, namely, transcortin.

The combination of corticosteroids and transcortin is obstructed by the haemato-encephalic barrier. The brain fails to receive information about the content of corticosteroids in the blood; this violates the feedback pattern and thus disturbs the regulation of the functions.

Stress influence rendered through the cerebral cortex and reticular formation cause changes (according to Kassil) in the subcortical centres, and are conducive to vascular dystonia. Under such conditions these processes lead to the intensification of ischaemia and the development of angina pectoris or myocardial infarction. The processes of the development of these diseases are, of course, far more complicated than merely the imbalance between the requirement for and supply of oxygen to the heart muscle.

In mild hypoxia, a defensive reaction forms during the initial stage: the vascular wall starts producing adenosine which enters the blood with a dilative effect. This, in turn, improves the coronary blood supply. A major role in these processes is played by the neurohumoral regulatory link since the sympathetic nerve fibres trigger the vascular sphincters improving the coronary blood flow. Under the influence of emotional stress, however, the level of vasopressin also rises, and this increases the spasm of coronary vessels.

Thus, it may be stated that neuro-reflexive reactions developing during these processes cause disorders in the coronary blood flow in different ways: on the one hand, as a result of the spasm of coronary arteries, the flow of blood to the myocytes is reduced. On the other hand, due to the increased production of catecholamines, their metabolism changes and demands more oxygen. All of this increases the deficit of oxygen in the myocardium. Moreover, catecholamines have an atherogenic influence on the coronary arteries and cause the formation of thrombi in them.

The influence of a variety of unfavourable factors disturbs lipid, partly protein, and carbohydrate metabolism against such a background and all the conditions are created for atherosclerosis of the coronary arteries to develop. The intensive development of the atherosclerotic process is compounded by the hypertensive disease, the disturbance of tolerance of carbohydrates, particularly diabetes mellitus, as well as by hypothyreosis, alcohol, smoking, all kinds of stress, hypokinesia, etc.

Disorders of the coagulative and anticoagulative blood systems are also significant factors in the development of ischaemic heart disease. It is an established fact that most patients having ischaemic heart disease suffer from hypercoagulation (which is more pronounced at night than during the day). It is quite possible that coronary thrombosis occurs mostly at night whenever the diurnal biorhythm might be disrupted.

The cohesion of thrombocytes increases under the influence of

phospholipids, the level of which is high in the blood in ischaemic heart disease. Not only is the equilibrium of the coagulation blood system upset during this disease, but the activity of the anticoagulation system is also depressed.

One should remember that the principal source of energy for the contraction of the muscle is provided by the disintegration of adenosine triphosphoric acid, which catalyses by means of the adenosine triphosphatase enzyme. The transformation of chemical into mechanical energy, which serves as the source of muscular contractions, is brought about by the synthesis and disintegration of adenosine triphosphoric acid. Of lesser importance in this process is the disintegration of creatine phosphoric acid and glycogen. The former splits into creatine and phosphoric acid, while glycogen forms lactic acid in the process of glycolysis. Glycolysis, dephosphorylation of adenosine triphosphoric and creatine phosphoric acids are accomplished anaerobically. This process is accompanied by the accumulation of lactic acid and the products of disintegration of creatine phosphoric and adenosine triphosphoric acids, which cause muscle fatigue. Simultaneously with these processes, the transportation function of blood ensures delivery to the working muscle of energy and formative materials, oxygen, and trace elements, which, when the muscle is at rest, are used to compensate for energy expenditures, for the synthesis of protein and the accomplishment of redox processes in the muscle.

Meanwhile, the intensive work of the muscle without sufficient oxygen diffuses the lactic acid formed in the muscle into the blood and enhances its content. Under these conditions the concentration of ammonium and other products of the disintegration of adenosine triphosphoric and creatine phosphoric acids is also increased.

The work of the heart does not cease, and the heart muscle possesses certain unique features: metabolism is accomplished aerobically; during intensive work lactic acid does not accumulate during glycogen disintegration. This is due to the predomination of aerobic over anaerobic processes in the heart muscle. Moreover, lactic acid serves as one of the main sources of energy for the myocardium. Pyroracemic acid, glucose, glycogenic amino acids, fatty acids and others serve as energy materials. In recent years new facts have been established in the mechanism of energy formation in myocardial contraction. Chazov et al. (1975) demonstrated that the mitochondria isoenzyme, the activity of which constitutes 33-45 per cent of the total cellular activity of creatine phosphokinase, is capable of fully ensuring energy output from the mitochondria of the muscle cell in the form of the chemical energy of creatine phosphate molecules in the presence of catalytic amounts of adenosine triphosphate or adenosine phosphate. This conception maintains that the main role in supplying the myocardium with energy under aerobic conditions belongs to

creatine phosphate and not to adenosine triphosphoric acid. Adequate loads on patients affect not only the chemical composition and morphology of the myocardium, but the enzymatic processes providing the energy substances for activating the contraction mechanisms of the myocardium. It is interesting to note that during the process of evolution the adaptive mechanisms of the myocardium shaped to overcome the difficulties which arise during the life-sustaining activity of the organism. In the first place, the myocardium utilizes lactic acid to adapt its contractive ability for incessant work; in the second place, despite the lack of oxygen, the myocardium is capable of resorting to the anaerobic method for the direct transformation of glucose into lactic acid (the skeletal muscles are incapable of this); thirdly, the myocardium possesses a peculiar protein called myoglobin which has many of the properties of oxygen. It can be released only under low partial pressure when conditions for the blood supply to the myocardium are hampered. This is particularly obvious when there develops a disproportion between the needs and supply of oxygen to the heart muscle.

All this testifies to the fact that with the development of ischaemic heart disease, complex biochemical and structural changes occur which lead to, on the one hand, a decrease in cellular metabolism, causing dystrophic changes and death of cells, and, on the other, protection of cellular structures from death owing to those compensatory mechanisms which develop due to the central and local links regulating cellular metabolism. These regulating links not only improve the blood flow in the myocardium, but alter local metabolic processes in myocytes and connective-tissue cells, eliminate the critical state of these processes and save myocytes from inevitable death.

The ischaemic heart disease becomes manifest considerably later than the appearance of any kind of obstructions in the coronary blood flow. The patient goes to see his doctor only when he experiences pain in the heart, suffers from dyspnoea and from other subjective sensations making his life and work difficult. One of the most frequent manifestations of ischaemic heart disease is angina pectoris.

The development of angina pectoris, i.e. an attack of retrosternal pain, is often attended by cold perspiration, palpitation, a feeling of impending death, reflexive pains in the left hand and arm, particularly in the index and middle fingers or in the space between the inward edge of the shoulder blade and backbone, in the jaw, the root of the tongue or even by pains in radiocarpal articulations.

The pain syndrome in angina pectoris testifies to the connection between spasms of the heart arteries and the lack of oxygen supply to the heart muscle, which leads to hypoxia and to the accumulation of insufficiently oxidized metabolic products.

Such a clinical state very often makes the patient cry out for help

because the tissues of his heart muscle are suffocating from lack of oxygen. If the attack results from functional changes in the neurovascular apparatus of the heart, it is possible to eliminate the pain by means of vasodilative agents and the patient virtually recovers. If, however, such pains (angina pectoris) occur against a background of sclerosed coronary vessels and there are solid atherosclerotic plaques in the lumen of the vessels obstructing the flow of blood. more vigorous measures must be resorted to (intravenous injections of various drugs, oxygen inhalation, etc.) so as to eliminate tissue hypoxia and pain, and to relieve the patient of the fear of death. It is most important, however, to establish what actually caused the spasm so that the doctor might be correctly oriented for administering proper medical aid in good time (Bogolyubov, 1980).

Three forms of angina pectoris are distinguished by their clinical course: (1) the angioneurotic form, which most often occurs during emotional excitement, particularly in neurotic persons with a labile nervous system, who react instantaneously to a spoken word that inflicts a psychic trauma. In such instances, the spasm of the coronary vessels may occur centrogenically, i.e. via the central and vegetative nervous system, or by enhancing the reactions of the sympathicoadrenal system which discharges an excessive amount of catecholamines into the humoral medium. The resulting effect has been described above. When there is a disproportion between the demand for and supply of oxygen to myocytes, an attack of angina pectoris occurs; (2) angina pectoris of effort develops as a result of physical overloads which demand an increased blood supply to the skeletal muscles, a demand which the myocardium cannot satisfy. This results in a disturbance of the supply and demand relationship between the heart muscle and oxygen. In angina pectoris of rest progressive atherosclerosis leads to the narrowing of coronary arteries and the blood deficiency in the myocardium is so marked that it fails to ensure metabolic processes in the myocytes even in a state of rest; (3) a form of angina pectoris, the clinical course of which is both complex and variable, attended by cardiac asthma and the disturbance of rhythm, which leads to the development of cardiac failure (Shkhvatsabaya, 1975).

In each of these forms of angina pectoris, different changes in the function and structure of myocardial cells are noted. These changes are attended by numerous clinical manifestations which physicians take into account when diagnosing the disease and prescribing drugs, combined physical methods of treatment, and secondary prophylaxis to prevent new attacks and the advance of ischaemic heart disease (Bogolyubov, 1983).

It should be borne in mind, however, that the character of manifestation of the ischaemic heart disease does not always correspond to the degree of stenosis of the vessels and the spread of the atherosclerot-

ic process in the coronary basin. This, to a certain degree, is determined by a combination of general factors within and outside the heart which form the basis for the disease development.

Shkhvatsabaya (1975) emphasizes that in solving diagnostic problems when confronted with ischaemic heart disease, substantial importance, apart from clinical symptoms, belongs to three electrocardiographic signs: first, to focal-cicatricial changes of various duration and primarily to a change in the morphology of the *QRS* complex both in the presence and absence of attending changes of the *S-T* segment and *T* wave; secondly, to changes of segment *S-T* or wave *T* without a change in the configuration of the complex *QRS* typical of possible myocardial ischaemia; in the third place, to other electrocardiographic changes or non-specific deviations which are expressed by signs of hypertrophy of the left ventricle, and also to diffuse changes of an undefined nature, block of the bundle of His, etc.

The tolerance of patients suffering from ischaemic heart disease for physical loads decreases with the increase in number of damaged coronary arteries. This is why stage-by-stage load increases are widely practiced in cardiology. The length of each stage is 3-6 minutes. The load of the first stage which employs a bicycle ergometer is within the limits of 250-350 kgm/min. Subsequent loads are applied after a 3.5 minutes of rest. In treatment and rehabilitation of IHD patients, it is important to note how their tolerance for physical loads increases. This is particularly significant when applying natural therapeutic factors. The limit for physical loads is indicated by coronary insufficiency. This is why it is of great practical importance to establish the permissible threshold prior to treatment.

The next important question in the bicycle ergometry method is the position of the patient's body. The load test is conducted with the patient sitting on the saddle or in a lying position. In the latter instance, as a rule, the test must be stopped at a far smaller load. This is probably due to the fact that in a lying position the heart works 25 per cent more than when the person is in an upright position; the demand of the myocardium for oxygen increases and ischaemia sets in earlier. Experience shows that the higher the functional capabilities of the cardiovascular system, the greater the frequency of heart contractions under a load.

Marked symptoms of myocardial ischaemia are manifest in patients with ischaemic heart disease whose pulse rate equals 100-120 beats per minute. In slightly altered coronary arteries, the working capacity threshold is 575 kgm/min, whereas if there is a lesion of only one coronary artery it is reduced to 390 kgm/min and with a lesion of two arteries it drops to 300 kgm/min. With the increase in the number of coronary arteries involved in the pathological process, the frequency of the cardiac rhythm gradually slows down. In the opin-

ion of Aronov (1970), this corresponds to a reduced functional capacity of the heart while coronary atherosclerosis is intensified.

It should be remembered that when drug therapy is used in the treatment of IHD patients, not only potent vasodilative agents are administered which counteract the resistance of coronary arteries and stimulate collateral circulation, but also preparations are used which affect β-adrenergic receptors in the same way as antithyroid agents, which can lighten the work load of the heart and thus reduce the myocardium requirements for oxygen. Although anabolic agents enhance the working capacity of the myocardium, they do not increase the demand of the heart muscle for oxygen.

In recent years the pharmaceutical industry has been synthesizing a variety of antianginous, antisclerotic preparations, the agents which block β-adrenergic receptors, glycosides, antiarrhythmia preparations, and so on. These drugs are used to arrest attacks of angina pectoris, alleviate the course of ischaemic heart disease, reduce circulation disorders, disturbance of rhythm, and so forth. To change the course of the IHD, however, and particularly to prevent the advance of atherosclerosis of the coronary arteries, it is most necessary, for the purpose of prophylaxis, to apply natural and transformed physical factors both independently and in combination with drug therapy.

At the early stage of angina pectoris, when there are no organic lesions of the heart as yet, particularly in patients with the angioneurotic form of the disease or in patients with angina pectoris of effort, it is recommended to make extensive use of those natural physical factors which are capable of preventing the further development of these processes and, first and foremost, of arresting the advance of atherosclerosis of the coronary vessels.

Since the first form of the disease most often stems from nervous disorders (leading to disorder of neurovascular regulation, primarily of the coronary vessels), and, the second form, from atherosclerosis, it is of vast prophylactic importance to switch the overloaded nervous system over to another type of activity. This is why after arresting the attack of angina pectoris (the disappearance of pain, and the elimination of all clinical manifestations of the disease), it is very important for patients to be provided with organized rest and treatment at sanatoria to prevent the occurrence of new attacks. Under such conditions the patient, in the first place, gets away from all of his daily concerns and troubles, escapes from stress situations which intensify the tension of higher nervous activity and functions of the sympathico-adrenal system, thus eliminating the factors supporting and aggravating neurovascular dysregulation. In the second place, observance of the sanatoria time schedule (the regimen of motor activity, rest, meals and sleep, as well as of cultural and sports activities conducted by sanatoria personnel) makes it possible

to switch the activity of the central nervous system over to leisurely occupations, to lighten overloaded and to reload unevenly functioning portions of the cerebral cortex. In the third place, the beautiful surrounding landscapes, the pure fresh air, and correct diet are all conducive to adjusting the normal activity of the main systems of the organism: (a) first and foremost, the heart muscle with its complex vascular network; (b) the brain, which is extremely sensitive, particularly its cortical cells, to an oxygen deficiency; (c) the systems supplying other internal organs fulfilling a vital role in the normal life of the organism (liver, kidneys, intestines, skeletal muscles, bones and joints, etc.).

Besides all of the above-mentioned, psychoprophylactic measures are vitally important for this category of patients. Such measures exert a favourable influence over cortical functions which balance the processes of inhibition and stimulation in the cerebral cortex, over processes regulating the main functions of the cardiovascular system, and over processes rehabilitating the neurohumoral regulation, particularly in connection with changes in the performance of adaptive system, which occur after attacks of angina pectoris.

The function of the cortical cells is restored under the influence of psychotherapeutic measures, although at first the cellular structures become excited. Later the concentration of nerve processes enhances in limited areas. During the protective inhibition of nerve cells, their reaction to external stimuli is sharply curtailed. Inside the cells, however, restorative processes are intensified, resulting in the normalization of cortical activity, and the regulation of metabolism, particularly of lipids and lipoproteins, etc.

For such patients a correctly organized regimen is of major importance. A load of motor activity appropriate to the condition of the cardiovascular system, particularly at mountain-climate health resorts, improves redox and metabolic processes in the cells of the brain and myocardium, where these processes had been disturbed during the ischaemic heart disease. Constant physical training with an increasing load not only eliminates hypoxia, but improves circulation in the heart muscle by developing collaterals, intensifying gaseous exchange, transportation of energy and formative materials to the myocytes, evacuation of metabolites from the organism. Dosaged motor loads are most necessary for persons with hypokinesia which hampers circulation. The inclusion in active work of the skeletal muscles, which actually perform the role of the third factor of circulation (a factor created by the contraction and relaxation of cross-striated muscles of the extremities, which activate the venous outflow of blood), intensifies the supply of ven us blood to the right side of the heart (to the right auricle, and then to the right ventricle), thus improving the general blood flow. Improvement of the function of the large veins and of venous circulation has a favourable influence

on general haemodynamics, including coronary circulation.

Under the influence of various physical loads, the stroke and minute volumes of the heart increase, haemodynamic and electrocardiographic parameters improve. The physical loads and rate of expanding the motor regimen must differ depending on the severity of the myocardial lesion not only in different forms of angina pectoris, but also after a myocardial infarction has been suffered. Certain motor loads are indicated in cardiosclerosis, others in the state after myocardial infarction, and still others in mild cardiac failure or in disorders of the rhythm of heart contractions. This is why the motor regimen and its changes must be prescribed only by the physician in charge.

Of essential significance for patients with IHD stemming from atherosclerotic changes is the differentiated use of mineral (carbonate, sulphide, radon, iodobromine) baths, of electrophoresis with medicinal preparations (introduction of drugs by means of direct or pulse electric current), of sinusoidally modulated currents, ultra-high frequency electromagnetic waves, etc. Depending on the clinical manifestations of various forms of ischaemic heart disease, these natural and transformed physical factors are applied differently according to the peculiarities of the disease, the patient's condition, and the presence of attending or combined diseases, etc.

The patient must realize, however, that the effect of these factors, either independently or in combination with others, is not tantamount to the total effect of two or three elements of the given therapeutic complex. Therefore, the patients' requests to include additional elements of a given prescribed complex on the advice of friends who have benefited by such treatment are both erroneous and groundless. They are groundless because the disease develops in its own particular way in each individual patient. Patients tolerate physical loads differently depending on their coronary reserves, trained fitness and endurance, as well as on the mechanism of the healing effect of each factor separately and of the complex as a whole.

Mineral baths have a favourable effect on IHD patients: pains in the heart are alleviated, weakness, dyspnoea, and fatigue disappear. As a result of combined treatment, patients become active, more mobile, their working capacity increases and, depending on the character and severity of the dystrophic and ischaemic processes in the myocardium, they may return to their occupations.

Wherein lies the essence of the therapeutic effect of each type of the above-mentioned baths? How is the therapeutic and prophylactic effect under their influence achieved and how long does it last?

Patients with ischaemic heart disease are most frequently sent to health resorts rich in carbonate waters, because carbonate water has a favourable effect on the central nervous and cardiovascular systems, on neurohumoral regulation, renal function, the urinary and

other systems. After a carbonate water bath, the more so after a course of such baths, the skin becomes warmer, thermoasymmetry disappears (i.e. no difference in temperature on symmetric skin areas is registered), the skin takes on a rosy hue. After every bath some of the patients become sleepy. During the bath the pulse rate drops, respiration accelerates, and patients feel better. These facts testify that carbon dioxide and mineral salts have a stimulating effect on the skin surface, and via the nerve endings of the skin change the reactivity (speed of response reactions) and the tone of the nervous system. The impulses received by the central nervous system from the nerve endings (proved by experiments on animals by means of determining the function of the anterior hypothalamus), on the one hand, and the direct influence of carbon dioxide absorbed by the blood (via the lungs and skin), on the other hand, cause changes in the sensitivity of the vagus nerves nuclei, which decelerate cardiac activity, particularly the diastolic phase (a shorter time for the contraction of ventricles and a longer time for their relaxation); this decelerates the pulse rate and improves the blood-filling of the heart. Valedinsky (1938), the well-known resort specialist, used to say in such cases that when a patient takes carbonate baths, his heart is placed in a sanatoria regimen, i.e. it rests longer, its nutrition is better, and it works less. This is true, to be sure, because under such conditions the strength of the heart increases.

After a course of carbonate baths, cardiac output increases, intracardiac haemodynamics improves, signs of circulatory failure reduce or disappear completely. These integral indices of cardiac activity are evidence that under the vagotropic effect of carbonate water baths the blood supply of the myocardium becomes better and better during the cource of one month, its trophics are intensified, and coronary reserves increased. This improves metabolism in the heart muscle, eliminates foci of ischaemia, and strengthens the contractile power of the muscle. It is quite natural that under such conditions (as a result of the full combustion of fats and carbohydrates), energy processes in the myocytes are intensified and the supply of the myocardium with formative materials leads to an increase in the synthetic activity of the myocytes, the force of heart contractions, and to fewer possibilities for the deposit of cholesterol, β-lipoproteins, i.e. to the considerable weakening of the atherosclerotic process, particularly in the coronary vessels of the heart.

Physicians keenly observe successful metabolic processes in the myocardium, watching out for unfavourable reactions even to the point of aggravation of the disease, particularly of a hypertonic crisis if the patients are also suffering from hypertensive disease. If necessary, should such exacerbations occur, physicians alter the complex of therapeutic and prophylactic measures accordingly. This is particularly important if the patient has in the recent past suffered from

frequent attacks of angina pectoris or exacerbations of hypertensive disease.

In recent years, IHD patients have also been successfully treated with sulphide and radon waters which are prescribed with due account for the character of the course of the disease, the presence or absence of spasms of retrosternal pain, the increase of arterial pressure, and increased frequency of attacks. Therapeutic mineral waters are prescribed according to a variety of methods: different concentrations of hydrogen sulphide or radon in the water, different temperature and duration of baths, different frequency of procedures and different amounts of water in the baths: four- and two-cell baths, semibaths, baths, etc. Depending on the alterations in a method made by the physician during treatment, these procedures may be applied for therapeutic and/or rehabilitative purposes.

It must be emphasized that the physician decides all these questions taking into account the clinical manifestations of the disease, the biochemical and electrophysiological features found in IHD patients, particularly if the disease originated as a result of myocardial infarction.

In angina pectoris it is extremely important to establish which doses of sulphide and radon water would be conducive to the normalization of neurovascular processes. In postinfarction atherosclerotic cardiosclerosis, however, it is necessary to establish which doses would lead to substantial improvement of coronary circulation and of metabolic processes in the myocardium, to the improvement in the tonus of skeletal muscles, and to the elimination of hypokinesia. This is why, besides mineral baths, the therapeutic complex should include, in increasing doses, physical training exercises, motor activity, air baths, outdoor sleep or sleep on verandahs, etc.

In deciding whether to apply physical factors (artificial or natural) for therapeutic or for rehabilitative purposes, one must proceed from the following principal premise: the more active the developing disease the smaller the doses of physical factors are applied and in the least rigorous regimens, especially if there are indications that the blood supply of the myocardium is disturbed (even slightly), and in recently suffered (4-6 months) attacks of angina pectoris and heightened biochemical and enzymochemical indices. In such instances these factors are used for medicoprophylactic purposes. On the contrary, when blood supply has been restored, particularly in the myocardium, the cicatrization is normal, the patient is feeling well, and the biochemical, enzymatic and hormonal indices are also normal, the procedures should be increased in number and the motor loads enlarged. All these measures are aimed at developing the patient's endurance, eliminating hypokinesia primarily in the system of skeletal (cross-striated) muscles and internal organs, smooth muscles, improving circulation, activating redox and metabolic processes.

stimulating the function of adaptive systems, and increasing the working capacity. In these cases, the aforementioned factors are used for rehabilitative purposes.

In the first instance, the matter concerns the use of physical factors for purposes of treatment; with the instability of the most important functional systems of the organism, the loading method of applying physical factors may cause a breakdown in adaptive mechanisms, particularly of the cardiovascular system, because in these patients the system has been damaged by a pathological process, and the result may be the exacerbation of the disease or the appearance of complications. In rehabilitating patients, on the contrary, intensive methods in applying physical factors are intended to train the cardiovascular and control systems, as well as the systems which provide the organism with formative and energy materials, to increase the resistance of the organism, to build up the patient's endurance of psycho-emotional stress and physical loads, to restore the patient's mental and physical equilibrium to the level which existed prior to the disease.

Under the influence of mineral water baths, substantial shifts take place in the tonus and reactivity of the nervous system, in neurohumoral regulation, in central and peripheral haemodynamics. The increase of the adaptive-trophic function of the sympathetic nervous system improves trophics primarily by means of the feedback mechanisms in those organs and tissues where it had been disturbed. Mineral baths exert a complex influence on the myocardium via the neuroreflexive link, as a result of which the functions of contraction and the conducting system of the heart are greatly improved. At the same time, mineral water baths improve the regulating function of vascular collaterals. The baths increase the load on the myocardium because of the increased venous return of blood, but the conditions of its work are made easier at the expense of peripheral circulation. The time of the diastole is lengthened, the redistribution of the minute volume of blood changes, and blood supply to the myocardium is thus improved. These haemodynamic shifts are conducive to the development of compensatory mechanisms, evidently due to the functioning of intermural branches, inter- and intra-coronary anastomoses as well as of arterioles and capillaries. As the blood supply to the myocardium improves, there are fewer disorders in its contractive function: akinesia, dyskinesia, and asynchronia. The improvement of the vascular tonus within the myocardium removes spasm (pains disappear), transportation of oxygen, formative and energy materials becomes better, as well as of hormones, mediators and biogenic amines, first and foremost, of adrenaline and norepinephrine, and this acquires major significance in changing the correlation of anaerobic and aerobic metabolism in the muscle cells of the heart. Energy expen-

diture is reduced because the time of the diastole lengthens and the metabolites are evacuated more rapidly.

Spasmolytic agents exert a direct influence on the smooth musculature of the walls of the coronary and peripheral arteries, and their pharmacodynamic effect is evident in the changed metabolism of the myocardium, aiding the accumulation of metabolites which accelerate the arrest of the spasm. Mineral baths exert an influence through the neuroreflexive link by their gas and trace element composition: hydrogen sulphide acts as a powerful reducer; radon as an α-emanator; carbon dioxide produces a vagotropic effect. Cellular metabolism changes in different ways as a result of different mineral water baths. Substantial changes in cellular metabolism develop under the influence of sulphide baths because of the inclusion of sulphhydril groups and trace elements in the chain of biochemical transformations of the cytoplasm, cellular organelles and their enzyme systems. When hydrogen sulphide penetrates the cell, it affects the membranous structures, particularly the membranes of the mitochondria: their permeability is increased and the space between the inner and outer membranes expands. The changes noted through an electron microscope in the mitochondrial apparatus depend on submicroscopic and molecular changes which in turn alter the processes of intracellular respiration and oxidative phosphorylation. In some instances, when sulphide baths of low concentrations are used, hydrogen sulphide enhances intracellular metabolism. In other cases, under the influence of high concentrations, penetration of hydrogen sulphide into the cell increases, and a separation of the processes of respiration and phosphorylation takes place in the mitochondrial apparatus, which evidently results in the change of their morphological structure. Such metabolic disorders in the myocardium may cause a vascular spasm. Under the influence of sulphide baths the synthesis of creatine phosphate in the mitochondrial system is accelerated, and the process of oxidative phosphorylation is improved. These changes have a positive effect on the force of muscular contraction and improve intracardiac haemodynamics. Nevertheless, the positive dynamics of total cholesterol, β-lipoproteins, and triglycerides is still insufficiently expressed.

To choose the appropriate method for applying sulphide baths also requires caution and a sparing principle, because large doses of hydrogen sulphide may cause spasms and ischaemia, greatly intensify redox processes and, therefore, help the accumulation of creatine phosphate, adenosine phosphoric, adenosine monophosphoric acids, and inorganic phosphorus, which is inadequate for the blood supply of the myocardium.

As has been mentioned, the specific influence of carbonate (effervescent) baths is a result of the vagotropic effect. It must be remembered, however, that in a dilated heart, particularly one suffering

from an insufficient contractive function of the myocardium, there is an increased diastolic volume of blood and high terminal diastolic pressure in the left ventricle, which builds up the pressure on the ventricle walls, causing a larger consumption of oxygen and a decrease of blood perfusion in the subendocardium. In this process, compression pressure mounts, which naturally has a negative effect on tiny coronary arteries (arterioles and capillaries) fulfilling the function of the autoregulation of the coronary blood flow. In this case, mineral baths should be supplemented by the prescription of digoxin aerosols. Neurovascular components of a sympathetic nature conducive to enhancing myocardial trophics become involved against such a background. The delivery of oxygen, energy, and formative materials is increased, and under such conditions they are required less, because towards the end of the course of treatment the vagotropic effect of carbonate bath causes the myocardium to stabilize (it contracts more slowly, the diastolic and minute volume of blood increases, coronary blood supply improves and the evacuation of metabolites from the myocardium is stepped up). All this helps to make better the metabolism and rehabilitate intracardiac haemodynamics.

Under the influence of carbonate baths, oxygen consumption by the myocardium is reduced because the heart is working more effectively due to the vagotropic effect. Under the influence of radon baths, the functional activity of the sympatho-adrenal system is increased, the sensitivity of α- and β-adrenoreceptors to steroids is enhanced, and a permissive effect is manifested as a result of which the trophics and cardiodynamics of the myocardium are improved. However, with an inadequate dose of radon baths via the above-mentioned mechanisms hypoxia of the myocardium may increase. This is why the dosage of radon baths must be prescribed with caution in regard to the concentration of radon, temperature, the length of procedures, and in relation to their frequency, character and succession in the treatment complex which includes other procedures such as hydrokinesitherapy, etc.

If stable angina pectoris is diagnosed in patients suffering from postinfarction atherosclerotic cardiosclerosis at a time when the above-mentioned baths cannot be applied, it is expedient to include 'dry' carbonate (called mofette) baths. The principal component of the therapeutic effect of these baths is carbon dioxide which renders a versatile influence over the neuro-reflexive and humoral processes developing in the organism. When it enters the body through the skin and mucous membranes, the gas affects the vegetative regulation of cardiac activity, cardiohaemodynamics and the blood-filling of the cerebral vessels up to the microcirculatory bed.

The carbon dioxide entering the internal medium of the organism also produces a vagotropic effect, lengthening the diastole, intensi-

fying myocardial metabolism and heightening its contractive ability. The gas accelerates the coronary blood flow and increases the oxygen volume in the blood. It should be noted that the hydrodynamic component of these baths in this case is excluded and this is why such mofette baths can be prescribed for a patient who is more severely ill with coronary and mild cardiac failure. Portnov (1983), a scientific colleague in one of our clinics, demonstrated that the therapeutic effect of 'dry' carbonate baths is more pronounced at a temperature of 28 °C than at a temperature of 32 °C. In the majority of patients with postinfarction cardiosclerosis, 'dry' carbon dioxide baths reduce the frequency of angina pectoris attacks, or the attacks disappear completely. There are fewer clinical signs of insufficient blood flow, and the dynamics of electrocardiographic indices improve (the reduction of ischaemia, overloading of the left auricle, increased amplitude of low-voltage *T* waves, etc.).

Even just one 'dry' carbon dioxide bath increases the low partial tension of oxygen in capillary arterial blood, while an air-vapour bath does not induce any substantial changes in this respect. The most typical reaction of cerebral circulation in response to one 'dry' carbonate bath consists of the deceleration of the blood flow in the carotid arteries and its acceleration in the ophthalmic arteries. The increased voltage of initially low *T* waves on the ECG, which indicates improved metabolism in the myocardium, has been registered in one out of two patients.

It is a curious fact that a reduction in the venous return to the heart during the prolongation of diastole due to less frequent heart contractions and the 'afterload' on the myocardium, which is confirmed by the lowering of diastolic arterial pressure after the procedure, is evidently caused by the removal of sympathetic vasoconstrictive influences over the smooth muscles of the arteries and veins in the simultaneously direct and reflexive vasodilative action of carbon dioxide on the voluminous and resistant vessels. The reduced 'preload' and 'afterload' on the myocardium, the increase of the coronary blood flow and oxygen volume of the heart, the lengthening of the diastole, all lead, on the one hand, to a reduced demand by the myocardium for oxygen, and, on the other, to the greater consumption of oxygen by the myocardium. This results in joining the processes of synthesis separated in ischaemia of the heart with insufficiency of circulation and the consumption of energy in the myocardium.

Under the influence of mofette (gas emanation) baths, attacks of angina pectoris of effort disappear in five sixths of all patients, while in the same category of patients air-vapour baths cause more frequent attacks of angina pectoris of effort accompanied by the appearance of depression of the *ST* segment on the ECG in one fifth of all patients. Under the influence of air-vapour baths arterial

pressure decreases in half the patients if it had preceded the development of myocardial infarction.

When prescribing mineral baths of any composition for patients suffering from ischaemic heart disease, it should not be forgotten that small doses intensify cellular metabolism while large doses depress it. The length of baths may prove to be inadequate for the intensity of development of the disease, causing unfavourable balneopathological reactions to the extent of exacerbation of the ischaemic process in the heart. If the patient is in a bath for more than 30 minutes, it may cause negative haemodynamic shifts and general weakness. The incorrect prescription of mineral baths may cause a decrease of arterial pressure, paralleled by a drop in perfusion coronary pressure and the possible development of an attack of angina pectoris. This is why a correct individual prescription adequate to the condition of the patient is of major importance for inducing favourable vascular responses. Moreover, at the beginning of a course of treatment the doses must be minimal and dynamic, depending on the condition of central and peripheral haemodynamics.

A careful, thoughtful approach to the choice of the physical factor and the method of its application will greatly promote the achievement of a high therapeutic effect.

Thus, the effect of a course of mineral baths, whether carbonate, sulphide, or radon on IHD patients leads to changes in haemodynamics, the function of external respiration, the development of redox processes, cellular metabolism, and helps to restore the disturbed functions of various organs and systems. Under the influence of these baths and the patient's motor activity, the additional factors of blood circulation become intensified, e.g., the excursion of the diaphragm expands and the contraction of intercostal muscles improves; all this improves the function of external respiration.

The method of applying mineral baths must be differentiated depending on the way IHD is clinically manifested. Patients with mild or rare attacks of angina pectoris without pronounced vascular dystonia should be prescribed carbonate baths with a concentration of 1.2 g/l of carbonic acid according to the following method: water temperature, 34-35 °C; length of procedure, 7-12 minutes; every other day with a total of 10 to 12 baths. For IHD patients with a hypotonic syndrome accompanied by deteriorated metabolism of the myocardium, carbonate baths are recommended at a temperature of 33-34 °C for 6-10 minutes every other day with a total of 10 baths. Patients with a hypertonic syndrome are prescribed carbonate baths at a temperature of 35-36 °C up to 15 minutes long for a course of 12-14 baths.

In cases of IHD with atherosclerotic coronarocardiosclerosis of recent origin after myocardial infarction (after 6-8 weeks) with no signs of cardiac failure courses of treatment are prescribed which

include two- or four-cell sulphide or carbonate baths with a 50-75 mg/l concentration of hydrogen sulphide at a temperature of 36-37 °C, 8-10 minutes long, every other day for a course of 12 baths. Carbonate cell baths are prescribed with a 1.5-2.0 g/l concentration of carbonic acid at a temperature of 34 °C, 6-8 minutes long every other day for a course of 10-12 baths.

One should bear in mind that if the attacks of angina pectoris in postinfarction cardiosclerosis are lengthy and frequent the patient should be treated with nitrates and their complex should include 'dry' carbonate baths (CO_2). Various apparatuses have been invented for this purpose, but the most effective for applying these baths is the 'ETH' model made in the Federal Republic of Germany. The rate of CO_2 delivery is 15 l/min. Air-vapour baths are applied according to the same principle, but without the delivery of CO_2. The relative humidity in application of 'dry' carbonate and air-vapour baths amounts to 100 per cent. The procedure is 10-20 minutes long and the course of treatment consists of 10 to 14 baths; temperature, 28-30 °C; terminal concentration of carbon dioxide is up to 30 volume per cent.

'Dry' carbonate, just as other baths, are contraindicated during the period of attacks and marked coronary and cardiac insufficiency.

Electric sleep (low-frequency pulse current) included in the complex of therapeutic treatment in IHD of recent origin produces favourable results. In the case of arterial hypertension, it is expedient to apply treatment of low intensity (low-frequency current of 5-20 hertz, in a procedure of 30-50 minutes). In such doses, pulse currents have a sedative effect and normalize neurohumoral regulation. In a hypotonic syndrome, quite the opposite occurs: pulse currents in the method of electric sleep are used for stimulating the functions of the main regulation systems in increasing doses beginning with 10-20 to 40 hertz with procedures lasting 20-40 minutes.

In chronic IHD after a myocardial infarction, the treatment may be repeated 8-10 months after the above-described course. In this case, balneotherapy should be intensified (if there are no contraindications in regard to the general condition of the patient). Instead of sulphide cell baths, common sulphide baths are used at a temperature of 36-37 °C in procedures of 12-15 minutes two days in succession with the third day off for a course of 12-14 baths. Carbonate baths are at first prescribed in the form of semibaths, then as common baths at a temperature of 33-34 °C lasting 8-10 minutes every other day for a total of 10-12 baths.

One should bear in mind that in IHD, particularly in postinfarction atherosclerotic cardiosclerosis, pharmacological preparations may be introduced into the organism by means of galvanic current. In doing it, the doses of these drugs are reduced, but their therapeu-

tic effect is enhanced and very often the side-effects of these agents are eliminated.

If the patient is suffering from chronic coronary insufficiency and cerebral atherosclerosis, a good healing effect is attained by iodobromine-electrophoresis via the generally accepted method: an electrode 300 cm^2 in area is placed on the back of the patient between his shoulder blades and connected with one pole of the galvanic apparatus, while two other electrodes 150 cm^2 in area are placed over the region of the gastrocnemius muscles and are connected with the other pole of the apparatus. The procedures, 20-25 minutes long, are conducted every other day in a course of up to 15 procedures. Patients may be prescribed euphylline-electrophoresis (a 2 per cent solution of euphylline) in a course of up to 20 procedures each 15 minutes long, two days in succession. If changes occur in the blood coagulation and anticoagulation systems, heparin-electrophoresis should be resorted to; density of current 0.03 mA/cm^2, length of procedure 20-25 minutes for a course of treatment consisting of 14-16 procedures. If angina pectoris is accompanied by tachycardia, it is expedient to apply platyphylline-electrophoresis. The dose of platyphylline for one procedure is from 0.02 to 0.04 g, density of current 0.04-0.06 mA/cm^2, with 14-16 procedures in one course of treatment. The procedure is carried out every day lasting 10-12 minutes. For such patients, euphylline-electrophoresis should be combined with therapeutic physical training exercises and massage.

To alleviate pain in patients suffering from angina pectoris, it is best to conduct ganglerone-electrophoresis by the method described for conducting iodobromine-electrophoresis. These procedures are also combined with therapeutic physical training exercises and massage, but they are not always sufficient for restoring a patient's working capacity. Many patients must be given additional drug therapy or take medication independently when it is impossible to prescribe physical methods of treatment.

All these problems are resolved on an individual basis with due consideration for the clinical course of the ischaemic heart disease. Of major importance for setting the principles of the therapeutic complex and elaborating adequate methods of application is the presence of local stenoses of coronary arteries, particularly when the collateral system in the coronary basin is insufficiently developed. It is even more difficult to tackle therapeutic tactical questions in cases of diffuse stenosing atherosclerosis of the coronary arteries. More often than not, such patients require aortocoronary shunting with the subsequent application of natural therapeutic factors for rehabilitative purposes.

In patients with primary manifestations of atherosclerosis of coronary vessels and a functionally insufficiently developed collateral network (this process most often stems from coronary-metabolic

dysadaptation and angina pectoris of physical or emotional effort is diagnosed), sulphide and carbonate mineral baths, climatotherapy, and dosaged motor activity depending on the methods of their application may produce a therapeutic or rehabilitative effect. In patients with diffuse stenosing atherosclerosis affecting the main branches of the coronary arteries, even with a very well developed collateral network, these factors had better not be prescribed because they may worsen the clinical development of the process, or they may be prescribed sparingly. After aortocoronary shunting (if coronary circulation improves), natural factors may be sparingly prescribed for such patients at the primary stage for therapeutic purposes, and at the secondary stage for rehabilitative purposes the methods of application may be intensified.

Natural, particularly balneotherapeutic, factors intensifying cellular metabolism, enzymatic, hormonal, redox and other energy processes may result (if they are prescribed at a stage of aggravation) in exacerbation of the ischaemic process, and exhaustion of reserves, especially coronary reserves. This increases the possibility of complications including thromboembolic. This is why the doctor must be extremely careful in deciding which natural factors can be used for therapeutic purposes in a certain case and which natural factors may be applied for rehabilitation.

Two-three months after an acute myocardial infarction, patients can be sent to local sanatoria located near the patient's residence.

With the adaptation of these patients to the sanatoria regimen, and the relief of the locality, it is recommended to begin rehabilitation with a small motor load. All the elements of the rehabilitative complex (low-frequency pulse currents, superhigh frequency electromagnetic waves, 'dry' carbonate, narzan, sulphide or radon baths, therapeutic physical training exercises, and massage) are intensified with the passage of time. Under the influence of all the factors of this complex, the tonus of the neuromuscular system is heightened, trophic processes in the myocardium are intensified, coronary reserves are enhanced, the compensatory mechanisms of regulation are improved, and the patient's endurance to loads builds up.

Depending on the initial condition of IHD patients, balneotherapy, climatotherapeutic procedures, and dosaged motor activity are prescribed individually and differently: in hypodynamia, decreased output of blood volume, hypotonia, delayed regeneration of the myocardium, and also in low vital volume of the lungs, minute volume of respiration, and minute ventilation of the lungs, these factors are prescribed in limited doses and applied by the least intensive methods. Patients are recommended to take short walks, terrain cure at a small angle of climb, mild physical training exercises.

After 2-3 weeks of their stay at a sanatorium, provided clinical indices are good, patients are subject to more intensive methods in the application of mineral baths, physical training exercises, and larger doses of motor activity. At this stage active climatotherapy, hardening procedures, and increased motor loads are included in the complex. In clinical improvement of the patient's condition, drugs are either discontinued or the doses are reduced. Furthermore, in a favourable clinical course of the disease, all the elements of the rehabilitative complex are intensified. Under the influence of balneotherapy and motor activity conducted under conditions of sanatoria-health-resort treatment, the blood supply to the myocardium greatly improves, peripheral vascular resistance is reduced, central and peripheral haemodynamics normalizes, the intensity and rhythm of external respiration improve, the function of adaptive systems intensifies, and neurohumoral regulation improves. All these processes enhance myocardial metabolism and are conducive to improving the course of proliferative and metabolic shifts at the site of the infarction. Preliminary therapeutic preparation conducted by means of baths, physical training exercises, and dosaged motor activity allows for the transition to the second stage, that of rehabilitation. This stage is characterized by diminished drug therapy and a more active use of physical factors. Furthermore, comprehensive measures are undertaken to restore professional working capacity; for some specialities, the method and volume of work should be adapted to the modified physical capabilities of the convalescents. Psychological readaptation is of primary importance. It is essential to rebuild the patient's self-confidence and assure him that he is sufficiently skilled to work and valued as a full-fledged member of society. In many instances, the training of new professional skills is required in accordance with the patient's mental and physical abilities.

The concluding stage of rehabilitation is concerned with controlling the results of restorative measures. Regular observation of the convalescents makes it possible to determine whether or not the initial direction of occupational readaptation was chosen correctly, to establish the efficacy of rehabilitative measures, and to see if it is necessary to revise the plan of rehabilitation in order to attain better results.

Long years of observation and special research have shown that the correct evaluation of the condition of patients and appropriately prescribed therapeutic and rehabilitative measures according to the individual features of convalescents can promote the restoration of their working capacity.

Chapter 7. Physical Therapy of Patients with Hypertension

The pace of modern life, the urbanization of communities, technicalization and automation of production, undoubtedly, create increased loads for the nervous and cardiovascular systems. No smaller a working load burdens the other systems controlling and supplying the human organism. These loads could be compensated for and endured with the help of adaptive mechanisms and devices originating in the process of the vital activity of the organism, if people themselves would not create additional stress which can form the basis of various diseases, including hypertonic and hypotonic diseases.

Hypertensive disease is the most common affection of the cardiovascular system. According to the data of epidemiological investigations (1976), high arterial pressure is registered in 10-15 per cent of all adults, and in some populations this figure reaches as high as 30 per cent.

Hypertensive disease considerably reduces the life span and results in a high incidence of invalidity and mortality (Arabidze, 1977; Ilyinsky, 1977). It is worth noting that arterial hypertension is accompanied by functional and structural changes in the vessels of the brain. In such patients, angiography and rheoencephalography reveal an increased tonus of the cerebral vessels, loss of their elasticity, and changes in blood filling (Vinichuk, Krinchuk, 1981; Troshin, Kuznetsova, 1981; and others).

Various risk factors and stress, particularly 'verbal stress', may be so powerful, that they quickly lead to overstrain of the functions of the organism's control systems, primarily involving the more reactive nervous system. Neurosis results from the clash of stimulating and inhibitive processes in the cerebral cortex. It should be emphasized that alcohol, smoking, noise, and other unfavourable factors may cause neurosis which, in its turn, forms the basis for the development and clinical manifestations of hypertensive disease.

Stage I of this disease is none other than vascular neurosis which develops progressively. With time, under the influence of unfavourable reactions, vascular neurosis gathers momentum in its develop-

ment and new links of pathogenesis appear against the background of the nerve component. These links are atherosclerosis of the main arteries, disorders in the function of the renin-hypertensive system, as well as metabolic disorders, particularly those that lead to obesity, a decrease in tolerance (endurance) for carbohydrates, and to the development of diabetes mellitus, etc. Each of these abnormal processes aggravates the clinical course of hypertensive disease.

Myasnikov (1960), the outstanding Soviet cardiologist, stressed that hypertension and atherosclerosis do not exist independently, that there is only one disease which is manifested in some individuals as hypertension and in others as atherosclerosis and more often than not by both morbid processes simultaneously or in direct succession. This is why it must be borne in mind that the progressive development of atherosclerosis aggravates the course of hypertensive disease and, vice versa, the intensive course of arterial hypertonia negatively influences the atherosclerotic process, especially when it affects the coronary and cerebral arteries. Elevated arterial pressure keeps increasing the load on the heart, often complicating the clinical course of IHD. The hypertonic crisis may often even herald the development of myocardial infarction. For this reason the presence of these diseases calls for both the doctor and patient to adhere scrupulously to a strict regimen of work and rest.

True, hypertensive disease may develop independently over a long period of time without serious changes in the heart, and in this case it does not have such a negative effect on the general condition of the patient, on his working capacity and activity.

Myasnikov pointed out that arterial pressure elevates as a result of the initial disturbance of the cortical and subcortical regulation of the vascular system as a result of a disorder of higher nervous activity, with the subsequent involvement of hormonal factors in the pathological mechanism.

The development of the disease is conditioned by shifts in humoral pressor and depressor mechanisms which at the beginning are of a compensatory nature. The influence of the central nervous system over the tonus of arteries, arterioles, and the myocardial function is exerted through the sympatho-adrenal system, including the vasomotor centres of the hypothalamus, sympathetic nerves, adrenals, α- and β-adrenergic receptors of the heart and vessels. The increased activity of the sympatho-adrenal system causes changes in the motor and contractive function of the myocardium and constriction of the arterioles.

It is presumed that because of the direct influence of the sympatho-adrenal system over the juxtaglomerular apparatus of the kidney, the renal blood flow increases and this leads to more frequent urination and the intensified excretion of sodium ions. The enhanced discharge of sodium stimulates secretion of aldosterone by the adrenals.

Aldosterone is a hormone which helps to retain sodium in the organism, mainly in the walls of the arterioles. This makes them particularly sensitive to pressor reactions, particularly to the influence of mediators of the sympathetic nervous system.

Besides aldosterone, catecholamines also play an important role in heightening the vascular tone. The increased flow of adrenaline into the humoral medium in its turn causes increased spasms of the capillary system. All this, to a greater extent, hinders the capillary blood flow in various organs and aggravates the course of the disease.

An important role in the pathogenesis of arterial hypertonia belongs to the interrelationships between hypertensive and antihypertensive factors. It has been established that the severity of arterial hypertension depends not only on the activity of the organism's pressor systems, but also on the condition of certain depressor systems including the kinin system, the activity of enzyme, inactivating angiotensin, and prostaglandins also produced by the kidneys.

The biologically active substances mentioned above play a major role in changing the functional state of the cardiovascular system. They exert both a stimulating and an inhibiting influence over the neuro-endocrine mechanisms regulating vascular tonus and circulation. The homeostasis of basal arterial pressure is disturbed in the process of the changing interaction of these substances.

The increase of the cardiac output and stroke volume of blood, combined with other indications of the enhanced influence of the sympathetic nervous system, play an important role in the development of the disease. The vital pathogenetic links of hypertensive disease are constriction of the renal arteries, increased secretion of renin, intensified formation of angiotensin, increased secretion of aldosterone, retention of sodium in arterial walls causing their enhanced sensitivity to pressor factors. An important link in the pathogenesis of hypertensive disease determining the predomination of this or that clinical form is also ischaemia of vessels of the brain, heart, and kidneys, which occurs when these vessels constrict.

Ischaemic and stagnant disturbances of blood supply and hypoxia of the tissues of various organs, particularly of kidneys, acquire substantial significance.

An important role in the formation of arterial pressure is played by several factors: the minute volume of blood, its viscosity and degree of tonic contraction of the muscular walls of arterioles; the last factor is of utmost importance in elevating blood pressure. Neither the work of the heart in regard to the amount of blood thrust into the aorta in a unit of time, nor the increase in the blood viscosity, such as in polycythaemia, causes the least increase of arterial blood pressure if the normal regulatory function of the vascular tone is maintained, which is accomplished, as has been stated, primarily with the change of tone of the muscular layer of the arterial wall.

This is why in hypertension the increase of muscle tone in small arteries and arterioles, and the constriction of the lumen of capillaries and precapillaries determine the character and severity of the disease course.

Even at the early stage of arterial hypertonia, and especially in the second and third stages, there occurs an intensified tonic constriction of the arterioles.

Along with the disturbance of cortical neurodynamics, i.e. complex processes regulating life activity, and with the functional disorder of vegetative pressor centres controlling vascular tone, substantial importance is acquired by changes in neurohumoral regulation (constancy of the inner medium of the organism). The disturbed balance between adrenergic and cholinergic substances results because of the increased tonus of the sympathico-adrenal system, and this leads to the disturbance of local and systemic blood flow, as well as to changes in the structure and function of the vascular wall, primarily of the renal vessels. Ischaemia of the renal parenchyma causes the dysfunction of the renin-hypertensive system, the increased production of renin, and the development of the pressor (vasoconstrictive) effect. A major role in increasing the tonus of vessels belongs to adrenal hormones, first and foremost to aldosterone, adrenaline, and noradrenaline. Adrenaline intensifies the spasm of capillaries and precapillaries. The aggregate effect of these changes increases peripheral resistance, reduces the flow of blood to cells, and increases arterial pressure. In some people suffering from hypertensive disease even of stage II, the second phase permits them to retain their working capacity; they are eager to work and pay slight attention to their disease. In other patients, quite on the contrary, the neurotic component is predominant. It is attended by endless psychoemotional complaints (irritability, tearfulness, insomnia) and particularly of a cardiovascular nature (pain in the region of the heart, headaches—forehead or back of the head, encircling the head). The former rarely go to a doctor for help while the latter think of nothing else. It is necessary, of course, to prevent the progression of the disease in both groups of patients, to determine the stage of its development for the most appropriate use of drugs and prophylactic measures, and particularly of natural factors to build up health.

The most frequent complication of hypertensive disease is the disturbance of cerebral circulation. According to Smirnov (1975), the incidence of strokes in hypertensive disease patients in the 40-49 years age group is nine times that of people of the same age group with normal arterial pressure.

Psychoemotional tension, atherosclerosis of the cerebral vessels, and osteochondrosis of the cervical segment of the spinal column are also aetiological aspects in the development of hypertensive disease.

Clinical observations have shown that the development of hypertonic crises and the occurrence of an acute rise in arterial pressure are always secondary. This information is of major prophylactic significance, because the determination and elimination of the causes of these phenomena may prevent recurrent attacks and inhibit the development of transient disorders of cerebral circulation.

Depending on the character and severity of unfavourable exo- and endogenic factors comprising the hypertonic crisis, we may distinguish several groups of patients in whom the pathogenetic basis of these attacks is not the same.

In patients of the first group, hypertonic crises occur as a result of overstrain of the central nervous system and the disruption of the regulating function of the adaptive systems due to psycho-emotional overloads, disorders in the function of the sympathico-adrenal system, and the unfavourable influence of bad weather. It stands to reason that the frequency and severity of these attacks depend on how long hypertensive disease has been developing, on the development of neurotic decompensation, as well as on the intensity of stress processes. Reactions to these processes shift in time and this is why the attacks occur more often in the evening or at night.

In patients of the second group, hypertonic crises occur as a result of sudden ischaemia and hypoxia of the brain. This is often the case in patients suffering from osteochondrosis of the spinal column, in whom vertebrobasilar insufficiency and orthostatic hypotonia are diagnosed. Furthermore, these crises may occur as a result of vascular changes taking place under the influence of intensive drug hypotensive therapy. Selection of the drug and its individual dosage is of vast importance in preventing not only a hypertonic crisis, but disorders of renal function. There have been instances when the use of hypotensive agents has so greatly depressed arterial pressure, particularly in the renal vessels, that micturition stops for some time. This, of course, causes apprehension in both doctor and patient. In this situation, it is essential to stay calm when such dysuric phenomena occur and wait until the effect of the drug wears off; in 10-12 hours urination will resume. Secondly, it is essential to select the drug properly and prescribe doses individually.

Although the vessels of all organs are affected by hypertensive disease, signs of the affection of the brain, heart, or kidneys usually predominate among the characteristic clinical symptoms. Proceeding from this fact, Tareev distinguishes three forms of hypertensive disease: cerebral, cardial, and renal.

Four variants are distinguished according to the nature of the course of this disease: rapidly progressive (malignant); slowly progressive; nonprogressive; reverse development. Some authors are of the opinion that all cases of malignant arterial hypertension are of

a secondary, symptomatic, character. Others contend that they represent an independent nosoform.

Besides hypertensive disease of cortical genesis, or essential hypertension, there are symptomatic, or secondary, hypertensions: nephrogenic, endocrinopathic, angiogenic (connected with lesion of the aorta and large vessels), centrogenic (connected with an organic lesion of the brain), and stagnant (in heart disease complicated by cardiac failure, etc.). Any of these forms and other forms of hypertension are attended by crises.

Myocardial ischaemia may be a prerequisite for the development of a crisis. An attack of angina pectoris brought about by the insufficient supply of oxygen to the heart muscle often causes reflexive excitation of the central parts of the nervous system and also an increase in the function of the sympathico-adrenal system. As a result of these processes, more catecholamines are discharged, which not only increases the demand by the myocardium for oxygen, but also heightens the vascular tonus.

It has been mentioned above that weather factors have a negative influence over the course of hypertensive disease. It must be emphasized that the condition of patients becomes much worse because of meteopathological reactions which seem to herald hypertonic crises. They depend to a great degree on the season of the year, the Earth's magnetic field, and a complex of weather factors, as well as on solar activity. The adaptive systems, particularly in patients with hypertensive disease, are very sensitive to seasonal rhythms and heliogeophysical factors. The incidence of hypertonic crises is highest in March, April, May, and lowers in June and February. The most favourable time of the year for victims of the disease is August, September and October.

Lethality resulting from hypertensive disease is mostly registered in December, January, February, March and April. These facts are of major importance for the timely application of prophylactic measures to prevent crises.

This is why the timely diagnosis of hypertensive disease or of symptomatic hypertensions, the determination of their stage of development, the application of treatment appropriate to the patient's general condition of health acquire not only therapeutic, but great prophylactic importance.

In the initial stages of these diseases, particularly valuable treatment includes: aerotherapy, heliotherapy, sea bathing (thalassotherapy), mineral water baths (balneotherapy), the use of transformed physical factors by means of different apparatuses (physiotherapy), dosaged motor activity in combination with drug therapy or without drugs, all against the background of a rational regimen of everyday activity and meals. The prescription of hypotensive agents is usually begun with the administration of rauwolfia preparations. When

they are insufficiently effective apressin is added, which may be introduced per os or by phonophoresis onto the region of the kidneys. In stable hypertension, these drugs are replaced by octadine in combination with methyldopa (aldomet, dopegit) or reserpine. Ganglioblocking substances are used for the rapid hypotensive effect, particularly in hypertonic crisis. These drugs lower the tonus of the sympathetic and parasympathetic nervous system, and in hypertensive disease attended by gastric or duodenal ulcer, they can render a favourable influence on these diseases, too. In such instances, reserpine may intensify gastric secretion, intestinal peristalsis, and aggravate the clinical course of ulcerous disease. For this reason it should be used with much caution and in small doses in such a combination of diseases.

The question of dosage and tolerance of various medicinal drugs is very complex and depends on the individual features of the patient, the character and form of the disease. In many cases, the drugs are insufficiently effective or the patient develops a tolerance for them. Side-effects develop in many hypertensive disease patients and the doses of the drugs they receive must, therefore, be reduced, consequently reducing the therapeutic effect of the given drugs. These circumstances make it necessary to use natural therapeutic factors on a wider scale, either as an independent method or as one of the methods of combined physiotherapy in combination with transformed factors.

If the individual peculiarities of the patient, the condition of higher nervous activity, the character of the course, stage, and phase of the hypertensive disease, as well as the tolerance of procedures and drugs are not properly taken into account, it becomes impossible to decide on the correct comprehensive method of treatment (the third stage of the hypertensive disease is not subject to health-resort treatment). Moreover, to gain a clear understanding of the essence of pathogenetic therapy and the method of its application, it is necessary to know the mechanism of the healing effect of natural factors for the given disease.

The mechanisms of the effect produced by these therapeutic complexes at various stages of hypertensive disease are not the same, because the character and the degree of changes occurring in the organs and functional systems at different stages of arterial hypertension differ considerably. Since the pathogenetic basis of the disease is neurosis in hypertensive disease stage I, phase A, the complex of therapeutic measures is aimed at mitigating the neurotic reactions, regulating and restoring the relationships between cortical processes of excitation and inhibition, and normalizing the vascular tonus.

Of vast importance in restoring the function of cortical cells and in eliminating neurosis in hypertensive disease is the compensation

for the oxygen deficiency which develops in nerve cells that are supersensitive to hypoxia. This is why the wide access of patients to sea air saturated with oxygen, ozone, and air ions renders a direct positive influence over these processes. In combination with the haemoglobin of red blood corpuscles, oxygen comes into contact with the mitochondria of nerve cells and becomes closely involved in redox processes. Intensified gaseous exchange also acts favourably on cellular metabolism in the heart muscle, improving intracardiac haemodynamics and the blood supply to internal organs including the adaptive systems. All this ameliorates the functional activity of the control and supply systems, and also alleviates disorders of peripheral haemodynamics. Moreover, in hypertensive disease this also reduces the peripheral resistance of the capillary vascular network.

Furthermore, sleep in the open air or by the sea under comfortable (hygienic and temperature) conditions contributes to cortical processes still more, eliminating overexcitation of cortical cells and enhancing inhibitive processes.

The therapeutic influence of fresh air brings about favourable shifts in thermoregulation and redox processes. Changes in the humidity, temperature and movement of air, in their turn, build up the resistance of the organism. These meteorological factors render a hardening effect, and, consequently, thermoregulation mechanisms, gaseous exchange, and intracellular respiration become more stable. True, it must be borne in mind that increased humidity at a high temperature may lead to overheating. In indifferent and cool air baths, arterial pressure drops, but at a higher temperature and under ultraviolet radiation it rises. This is why in different clinical manifestations of arterial hypertension, various methods are used in applying the air baths.

Whether these procedures are applied in motion or at rest is also of substantial importance. The possibility for being in the open air and the length of time the patient can enjoy fresh air, whether clothed or naked, in calm weather or during a storm at sea, must also be determined by the physician in charge, because various circumstances induce positive reactions in patients with hypertensive disease and negative reactions in patients with hypotonia (low blood pressure). The observance of certain conditions reduces the risk of exacerbation, and more often enhances the medicoprophylactic effect of such influences.

To increase the inhibitive effect it is expedient to include electric sleep in the therapeutic complex for patients resting in a climatotherapeutic pavilion or ward. Such combinations, however, produce good results exclusively in individuals in which the inhibitive process predominates in the cortical activity. With the predomination of excitation process, patients quite often react negatively to such procedures.

Heliotherapy for patients with arterial hypertonia or arterial hypotonia should be administered by differentiated methods in accordance with strict indications. Sun baths must be conducted with due account for the stage and phase of the disease. The intensity of solar radiation is determined by the number of biodoses depending on the stage of the disease. For example, patients with arterial hypertonia stages IB and IIA are prescribed heliotherapy in an intensive regimen within the limits of 0.5-1.0 of a biodose at hours of the least heat effect. In early morning and late afternoon hours, the intensity of the effect of ultraviolet rays is not high. Their greatest intensity is registered from 11 a.m. to 1 p.m. In the afternoon, sunlight is enriched by infrared rays, while the intensity of ultraviolet rays is reduced. These are important points for the correct organization of heliotherapy.

Heliotherapy induces substantial changes in the organism. The intensity of its action is determined by the reactivity of the organism (its ability to react in this case to external radiation) and by the power (dose) of solar energy. Infrared rays mainly produce a thermoregulatory effect, while ultraviolet rays are capable of producing physicochemical and biological effects. In the first instance, infrared long-wave radiation penetrates to a depth of 4 cm. In the second instance, ultraviolet rays (up to 350-400 nanometres long) affect the skin only up to 1 mm in depth. The ultraviolet erythema leads to the formation of skin pigmentation protecting it from external influences. Ultraviolet rays facilitate the synthesis of vitamins, exert an influence on the formation of phosphoric compounds, activate the process of splitting cellular protein substances, and give rise to reflexive and neurohumoral effects.

Heliotherapy contributes to changing the vascular tonus, improves circulation in the skin, cardiac haemodynamics, and the blood filling of cerebral vessels. With properly selected solar dosages, physicians can reduce arterial pressure. This is possibly caused by the decreased tone of the sympathetic nervous system, and the increased content of depressor substances in the skin because they reduce the spasm of capillaries and thus weaken peripheral resistance. Changes in intracardiac haemodynamics and peripheral resistance under the influence of solar irradiation lead to a decrease in arterial pressure.

An increase in the amount of melanin in the skin, which causes 'sunburn', is certainly attributed to the hypotensive influence of solar irradiation. The melanophores of the skin (cells producing pigment) use the same 'raw material' for this process as that from which catecholamines are synthesized. The deeper the sunburn, the lower the level of catecholamines, and consequently, the less the spastic effect of the sun is manifest, particularly through the capillaries of the skin. If the hypertensive disease is combined with

ischaemic heart disease, however, heliotherapy quite often exacerbates the latter.

Thus, the question of prescribing sunbaths and in what doses is one that can only be decided by the physician in charge, and, moreover, only after a very close examination, especially of the nervous and cardiovascular systems.

Very often even after a brief period of solar irradiation of the upper portion of the back of a patient suffering from some cardiovascular disease, there are pains in the heart, increased palpitation, arrhythmia, and the patient does not feel well in general. This is why such patients may be prescribed heliotherapy only under certain conditions and by carefully planned methods.

Sea and river bathing constitutes an important element in the combined treatment of victims of arterial hypotonia or arterial hypertension. Such bathing has a versatile effect on the organism. During swimming the skin and neuromuscular systems become actively involved. There are changes in thermoregulation, intensified stimulation of exteroceptors, i.e. the nerve endings which send nerve impulses to the central nervous system, contributing to the rise of arterial pressure in hypotonia. The change of neurovascular relations in the skin weakens peripheral resistance, especially after bathing when the patient experiences warmth, which in turn reduces peripheral pressure, particularly in hypertension. As a result of reflexive reactions, central haemodynamics changes, cardiac output increases, coronary circulation improves, the cerebral vessels are more fully supplied with blood, and the systolic (maximum) pressure is reduced.

Sea water contains macro- and microelements the healing value of which is hard to overestimate. Sodium chloride constitutes four fifths of the total amount of salts and influences the exteroceptors of the skin, changing the electric potential of the anterior and posterior tubercles of the thalamus. One fifth of the dry residue of sea water consists of other chemical compounds and trace elements which play a major role in metabolic processes, first and foremost in the cells of the capillaries and arterioles. Such reactions against the background of the above-mentioned changes act favourably on the clinical course of hypertensive and hypotonic diseases. Moreover, sea bathing enhances neuromuscular reflexes which influence vascular zones, and this leads to a heightened tonus of the skeletal muscles, a decrease of arterial pressure in hypertension and an increase in hypotonia. A correlation is established between the tonus of the skeletal muscles and the tonus of the smooth muscles of vessels. This connection is expressed in the formation of a peculiar integral value comprised of changes in the lability of the central nervous system and the normalization of muscle and vascular tonus. A substantial role in these pro-

cesses is played by proprioceptive impulses which change the tonus and reactivity of the nervous system reflexively leading to the normalization of circulation.

Sea bathing, long walks in the fresh air, sleeping in the open air and air baths, all exercise the heart muscle, improve intracardiac haemodynamics, facilitate the saturation of blood and tissues with oxygen, and contribute to improving the function of the extracardiac mechanisms of circulation which participate actively in regulating central and peripheral blood supply. The rehabilitation of disturbed links in the chain regulating central and peripheral haemodynamics is vitally important for patients with hypertensive disease. It is precisely in these patients that the above-mentioned links are impaired to various degrees (beginning with gaseous exchange and ending with all the other metabolic processes), for it is they that to a certain measure determine the arterial and venous vascular tonus at different levels, ranging from the capillaries to the tonus of the large vessels, including the aorta.

In organizing comprehensive medicoprophylactic aid for patients suffering from arterial hypotonia and particularly for those suffering from arterial hypertension, the application of balneological factors is of vital importance, especially the use of carbonate, radon and sulphide waters. Their prescription is most effective in those stages of the disease in which climato- and thalassotherapeutic factors are insufficient for producing the desired healing effect. It is true that not all patients tolerate these balneological factors equally well: some people feel better after taking a course of carbonate or nitrogen-radon baths, others after a course of sulphide and iodobromine baths, and still others react more favourably to sodium-chloride or radon baths. The effect produced by the application of these factors is to a considerable degree determined by the method that is used: that which is fine for patients with the hypertensive disease stage IA is not always good for patients with stage IIB and even worse for patients suffering from symptomatic hypertension or even from hypotonic diseases. All these questions may be decided only by the physician, and not for all patients in general but in the process of application of these baths according to a certain definite method prescribed for the given individual.

The advance of various forms of hypertensive disease is to a large measure prevented by the named types of mineral waters used in different ways depending on the form and stage of the disease, the physicochemical characteristics of these waters, their gaseous and mineral composition, trace elements, and so on.

Under the influence of effervescent baths, semibaths or diluted baths, substantial changes occur in the organism, particularly in the activity of the cardiovascular and bronchopulmonary systems. This is caused by the fact that carbon dioxide, mineral salts, and

trace elements, just as the physical properties of these waters, widely influence the neurovascular system of the organism by means of their direct effect on the nerve receptors in the skin and on the development of both local neurovascular and general neuroreflexive processes encompassing the central mechanisms regulating circulation. As a result of the influence of free carbon dioxide and trace elements absorbed by the organism, vascular spasm is eliminated and biologically active substances accumulate in the skin acting favourably on the peripheral vascular resistance. Carbon dioxide also has a direct effect on the nuclei of vagus nerves and exerts a vagotropic effect on the myocardium, which is clinically manifested by a shorter systole and a longer diastole. This, in turn, enhances trophic processes in the heart muscle and lowers systolic pressure, acquiring major importance in lowering the maximum arterial pressure in hypertensive disease. Moreover, free carbon dioxide binds with the metabolites of blood, possessing hypertensive properties, and is evacuated from the organism. Simultaneously the trace elements become involved in metabolic processes, including processes in the myocardium, and thus exert a positive influence on central haemodynamics.

These facts testify that effervescent baths have a specific effect on the mechanisms which determine the basis of the development and course of hypertensive disease; this is why their medicoprophylactic role in treating these patients is very great.

Together with their influence on the neurovascular elements of the skin and mucous membranes, and the fact that they induce reflexive-vascular changes in the myocardium and other visceral organs, sulphide waters cause substantial changes in neurohumoral regulation of circulation and cellular metabolism.

It is an established fact that sulphide baths make the skin redden and that these reactions are attended by a considerable flow of blood from the internal organs to the periphery and by the elimination of vascular spasm, particularly in the capillaries and precapillaries. The elimination of this spasm reduces peripheral resistance, thereby weakening the important pathogenetic link which plays a major role in the clinical course of hypertensive and hypotonic diseases, as well as of symptomatic hypertension. The penetration of free hydrogen sulphide into the organism and its effect on the interoceptors of the vessels and blood depots, just as the action of these waters on the exteroceptors of the skin, results in reflexive vascular changes of the myocardium, the sinocarotid zone, and the development of some neurovascular processes which mitigate the clinical manifestations of these diseases. It is no less important that under the influence of sulphide baths, heart contractions become less frequent, the time of the diastole is increased; all this has a favourable telling effect on the level of maximum arterial pressure.

These changes are caused by complicated processes developing

during the application of sulphide baths, in the intervals between baths, and during the period of aftereffect.

In the first place, it is necessary to emphasize that hydrogen sulphide exerts a direct influence on chemoreceptors located in the skin and vascular zones; in the second place, it has been shown that hydrogen sulphide penetrates the blood through the skin and mucous membranes. The blood then transports it to various organs, even to the cellular structures of the cerebral cortex and hypothalamus. In their experimental studies, Kaplun and Kopteva (1971) showed that after sulphide baths, just as after the parenteral administration of hydrogen sulphide, H_2S is found in the cerebrospinal fluid. Concurrently changes occur in some functions of the cardiovascular system, respiratory and vascular reflexes, and the coagulative ability of blood.

It has also been established experimentally that sulphide baths lead to greater differentiated inhibition in increased indices of positive reflexes. Simultaneously when the permeability of the haemato-encephalic barrier is increased (under the influence of methenamine), the penetration of hydrogen sulphide into the organism increases too. In this case, inhibition is not enhanced but weakened and the stimulative process may either gain or lose momentum.

These neuroreflexive processes occurring under the influence of sulphide baths acquire great significance in treating victims of hypertensive disease, a disease which is primarily pathogenetically linked with intervertebral osteochondrosis of the cervical segment of the vertebral column. Clinical observations confirm that after a course of sulphide baths, there is less pain or it disappears completely in the occiput and the cervical segment of the spine. Headaches and dizziness disappear, as does the pain and uneasy feeling in the region of the heart; sleep improves and the patient does not get tired as quickly. Arterial pressure is substantially decreased.

Special investigation has shown that after a course of sulphide baths, the elevated level of copper and ceruloplasmin in the blood serum normalizes. Furthermore, the sodium level decreases, while the potassium level increases in the erythrocytes of patients suffering from hypertensive disease stage IIA, whereas in stage IIB the high level of sodium and potassium in the erythrocytes remains unchanged. The content of such a trace element as nickel does not change either under the influence of sulphide baths. Meanwhile, the level of manganese in the formed elements of blood rises only in patients with stage IIA of the disease. At the same time, due to the diminished content of copper, there is less adrenaline in the blood, which in turn, lowers the level of arterial pressure. These facts provide evidence that under the influence of sulphide baths, metabolic and redox processes undergo changes in patients with hypertensive disease of the above-mentioned origin; changes also occur in hormonal

and enzyme activity. These alterations are of substantial significance in improving the trophics of intervertebral disks, the stability of the spinal column, and in decreasing vertebrobasilar insufficiency; thus, they lead to a more favourable clinical course of the disease. A definite parallel exists between the character of changes in these processes and the dynamics of the principal clinical and vascular manifestations of the hypertensive disease.

A certain place in the combined treatment of hypertensive disease patients belongs to radon and radon-vapour baths. They should be prescribed primarily for patients whose case histories include overstrain of cortical activity and ruptured regulation of the function of adaptive systems. For this category of patients radon baths are applied by modulated method: a low concentration of radon, 20-40 nanocurie l, baths of short duration (8-10 minutes), comfortable temperature (36-37 °C), every other day for a course of 10-12 baths. These baths are combined with physical training exercises, dosaged walks coupled with terrain cure in the shade to protect patients from insolation. This therapeutic complex can also be combined with air baths.

Under the influence of combined treatment, the excitability of cortico-subcortical vasomotor centres is subdued, the pressor effect is reduced, since α-radiation and the by-products of radon disintegration 'block' to a certain extent the receptors of vessels and depreciat the effect of pressor factors. Accumulation in the humoral medium of histamine and acetylcholine which induce hypotensive action results in diminished peripheral resistance of arterioles and lower arterial pressure. Under the influence of radon baths, the adaptive-trophic function of the sympathetic system is enhanced, which contributes to the improvement of metabolic processes, including those taking place in intervertebral disks and cerebral vessels, to the reduction of hormones and enzymes possessing hypertensive properties, particularly of adrenaline, prostaglandins, aldosterone, and others. As a result of these shifts, myocardial metabolism is activated and the blood supply to the retina and kidneys is improved. The renal blood flow is ameliorated more markedly under the influence of radon baths than under the influence of sulphide and carbon dioxide baths.

As a consequence of these changes a good therapeutic effect is produced by radon baths, which is clinically manifest in the weakening of neurotic reactions, better sleep, the appearance of reserve in conflict situations, reduced nervous excitation, fewer headaches and spells of dizziness, the disappearance of unpleasant sensations in the heart region, the reduction of systolic and diastolic pressure. A parallel can be drawn between the character of the restoration of regulation of the adaptive system functions and clinical manifestations of the hypertensive disease.

These facts testify that radon therapy actually influences the

regulation and restoration of the functions of the nervous and vascular systems, which in turn weakens or eliminates clinical manifestations of the disease.

Radon-vapour baths are very efficacious in attaining a therapeutic effect in patients with hypertensive disease, particularly if it is of renal genesis. It should be remembered that radon-vapour waters steam up directly from the bowels of the earth. The concentration of radon in dried air may be as high as 66 nanocurie/l. This steam is fed through pipes into the patients' cabins. It has been established that with the mounting temperature of the steam, the humidity and concentration of radon also increase. Mamatmurodov (1980) registered that at 44 °C there is 73.5 g/m^3 of moisture, at 50 °C—89.7 g/m^3 and at 55 °C—131 g/m^3, which is far greater than the amount of steam necessary to saturate 1 m^3 of air at the corresponding temperatures. As for the concentration of radon, it was respectively 0.23 nanocurie/l at 41 °C, 0.7 nanocurie/l at 46 °C, 18 nanocurie/l at 52 °C, and 4.6 nanocurie/l at 57 °C. The optimum conditions for radon-vapour baths are a temperature of 44-46 °C (at a height of 120 cm from the level of the floor) and an exposure of 10 minutes. The radon-vapour bath is a complex procedure including radon inhalation and an air-radon bath.

Under the influence of a month-long course of treatment, headaches and unpleasant sensations in the heart region are alleviated, a feeling of lightness and vigour appears, and the systolic and diastolic pressure reduce. True, in elderly people temporary tachycardia appears, but it disappears rapidly, the time of the diastole lengthens and the systolic index increases. The treatment intensifies the renal flow of plasma. According to Mamatmurodov, in the hypertensive disease of stage IIA the renal flow of plasma increases by 29.2 per cent, and in stage IIB by 15.9 per cent; by the end of the course of treatment it is 639.6 $\pm$ 16.2 ml/min ($P < 0.001$) and 514.6 $\pm$ 25.2 ml/min ($P < 0.02$), respectively. The author emphasizes, however, that although renal haemodynamics improves virtually in all patients suffering from hypertensive disease, stage I-IIA, in stage IIB it improves only in half of these patients.

The data cited provide evidence that in patients of the second group there were pronounced changes in the renal vessels. Under the influence of radon-vapour baths, glomerular filtration and the filtration fraction ameliorated and began to normalize.

It is important to stress that in nearly all patients with hypertensive disease, stages I-IIA, considerable improvement was registered under the influence of the above-described method, while in those with stage IIB an improvement was observed in only 53.1 per cent. Clinical improvement and decrease of arterial pressure are accompanied by a veritable increase of renal plasma flow and blood flow. The filtration fraction is lowered.

Thus, in distinction from water-radon baths, radon-vapour baths may be successfully applied in treating not only young hypertensive disease patients but elderly patients (under 70 years of age) who also suffer from disorders of renal haemodynamics, diffuse cardiosclerosis with cardialgia, as well as circulatory insufficiency of the first stage. In areas of hilly terrain, such baths are contraindicated for IHD patients with focal cardiosclerosis, angina pectoris of rest and even of effort, and in circulatory insufficiency more advanced than the first stage.

Together with balneotherapy it is expedient to include transformed physical factors in the complex of treatment for hypertensive disease patients. The use of such factors is aimed at regulating and restoring the disturbed functions of cortical and vasomotor centres, and the functional condition of adaptive systems.

Every physiotherapeutic factor has an application that is most effective and possesses its own special features of the healing effect.

In hypertensive disease of the first and second stages of phase A, as well as in patients with attendant cerebral and coronary atherosclerosis, with ischaemia and hypoxia of the brain, low-frequency pulse currents should be applied by the method of electric sleep. Most effective are low-frequency pulses from 5 to 20 hertz, applied for up to 50 minutes for a course of 14-16 procedures. In hypertensive disease stage II phase B with marked diencephalic and cortical changes, the pulse frequency is increased to 100 hertz while the length of the procedure is shortened to 20-30 minutes. For a more pronounced therapeutic effect on the cardiovascular system, neurohumoral processes and particularly on lipid metabolism, and on the coagulation and anticoagulation systems of blood, it is expedient to reduce the frequency of pulses to 40-60 hertz after five-six procedures. The correct dosage of pulse currents brings about substantial improvements in the diencephalic region and in cortical inhibitive processes. The sleep becomes deeper and more prolonged.

A very positive therapeutic effect is achieved when sinusoidal modulated currents are used, applied by the electric sleep method whereby the electrodes are placed onto the oculomastoidal region, or as pure sinusoidal modulated currents applied directly to the neck-collar zone. In the first instance, the following method is used: depth of modulations 75 per cent; frequency 100 or 60 hertz; length of modulated current 1 sec and non-modulated current 1.5 sec; length of procedure 15 minutes.

Having undergone such a course of treatment, patients of the first group experienced an improvement in cerebral circulation, rheographic index was increased, and there was an authentic decrease in systolic, diastolic and average pressure. These haemodynamic shifts lead to a reduction of hypoxia of the brain, and better cellular metabolism, particularly because of a more intensified supply of

oxygen and improvement of the cerebral venous outflow. The electroencephalogram changes favourably, primarily the α-waves; their amplitude increases and the encephalographic picture is more favourable than it had been before treatment. At the same time, the cholesterol and lipoprotein level drops. Due to these changes there are fewer headaches, less dizziness, nausea and less frequent sensations of pain in the heart region, as well as an increase in working capacity. Moreover, pulse currents exert a positive influence on the functional condition of the diencephalic portions of the brain and the inhibition of cortical processes, which, in turn, improves sleep.

If the patient suffers from hypertensive disease and cervical osteochondrosis, it is expedient to apply sinusoidal modulated currents (SMC) to the region of the neck, particularly when instability of this spine segment has been established. If vertebrobasilar insufficiency or occlusion of a segment of the intervertebral artery is found by means of Doppler's method, then this treatment proves to be very effective. The alternating current is most often applied with a frequency of 100 hertz, and a modulation depth of 25-100 per cent. Special investigations have shown that under the influence of SMC, pains in the occipital region subside, the crunching sound in the region of the neck diminishes as a result of improved trophics of the ligamentous apparatus, and the cervical segment of the spine becomes more stable. The application of the method reduces systolic and diastolic pressure, alleviates headache and irritability, improves sleep and increases working capacity.

Clinical practice shows that if patients suffer from neurotic disorders and adaptive dysfunctions of the central nervous system, particularly after mental and emotional stress and disturbance of hormonal equilibrium, the use of sedatives and tranquilizers in combination with neuroleptics makes the patient feel better and alleviates the clinical manifestations of the hypertensive disease.

An important role in the treatment of patients suffering from hypertensive disease with attendant ischaemic heart disease is played by β-adrenoblockers and peripheral vasodilators. These agents, however, often cause side-effects and various complications. The use of apressin, particularly in therapeutic doses, may give rise to tachycardia, dyspepsia, etc. This is why the combined use of physical methods of treatment with drugs, particularly electrophoresis with euphylline, ganglerone, platyphilline, heparin, bromine, etc. has a very favourable effect on patients. At stage II of phase A it is expedient to prescribe bromine electrophoresis with a 5-10 per cent sodium bromide solution. An electrode 300 cm^2 in area is placed between the shoulder blades and connected to one pole of the apparatus; two other electrodes, each 150 cm^2 in area, are placed onto the region of the right and left musculus gastrocnemius and connected to the other pole of the galvanization apparatus. The density of the

current is 0.1 mA/cm^2. For the asthenic syndrome, general bromine electrophoresis is combined with caffeine electrophoresis.

For cerebral hypertension, the therapeutic complex should include electrophoresis on the neck zone with either a 2 per cent solution of euphylline or magnesium sulphate. The length of the procedure should be 10-15 minutes, strength of current 6-8 mA; the procedure should be conducted for two days with a day interval in-between, with 12-14 procedures per course of treatment.

A good healing effect is also produced by obsidan electrophoresis and apressin phonophoresis in hypo- and eukinetic types of circulation. It is expedient to prescribe obsidan electrophoresis in hypertensive disease of the stage I-II to produce a β-adrenoblocking effect. It must be noted that this method reduces the level of hyperkinetic reactions, slows down the heartbeat, decreases the stroke and minute volume of the heart and reduces arterial pressure. Obsidan electrophoresis and apressin phonophoresis produce a combined effect, on the one hand, by drugs, and, on the other, by galvanic current and ultrasound. The latter improve patency of drugs into the internal medium of the body and also render an all-round favourable effect on the sympathico-adrenal system and on neurohumoral processes. These drugs reduce peripheral resistance, improve metabolism and the processes of metabolite excretion, particularly of hypertensive character. Moreover, obsidan electrophoresis produces a favourable influence on hypertensive disease patients who also suffer from ischaemic disease which is manifested in attacks of stenocardia, atherosclerotic cardiosclerosis. At the same time, apressin phonophoresis is effective in the same forms of the diseases developing by the hypo- and eukinetic types of blood circulation, in bradycardia and high peripheral resistance (Levchenko, 1982).

In recent years, great importance is being attached to speleotherapy in the treatment of hypertensive disease. The investigations carried out by Pavliashvili (1982) revealed that a somewhat increased radioactivity, the ionization of air and stability of meteorological factors are typical of karst caves. The air temperature in a karst cave stays within the limits of 13.8-14 °C; absolute humidity is 15.4-16.0 millibars, relative humidity—98-100 per cent. Oxygen content in the air reaches 20.5-21.5 volume per cent, and carbon dioxide 0.30-0.40 volume per cent. There are no air currents. Radioactivity of air in the cave is $2.1 \cdot 10^{11}$-$5.7 \cdot 10^{11}$ nanocurie/l, the number of light negative air ions is determined at 3645 to 5832, and of light positive air ions within the limits of 5248-7200 per 1 cm^3. Highly dispersed aerosol contains up to 0.03 mg/m^3 calcium ions, 0.08 mg/m^3 magnesium ions and 0.09 mg/m^3 hydrocarbonate ions.

The combined effect of these factors during two-three hours induces substantial changes in the condition of patients suffering from hypertensive disease stage I phase B and stage II phase A. After the time

spent in the karst cave, all patients feel much better, headache alleviates, arterial pressure goes down, the activity of their cardiovascular and respiratory systems improves, the cardiac and stroke index decreases, peripheral resistance, maximum and minimum arterial pressure drop. Moreover, under the influence of speleotherapy there are favourable dynamics in the phase of the cardiac cycle: the contractile function of the myocardium improves, the left ventricle is less overloaded, there are fewer manifestations of chronic coronary insufficiency and better bioelectric activity of the myocardium (a shorter complex of *QRS*, *PQ*, and *ST* intervals). At the same time under the influence of the course of treatment, there is a change for the better in the functions of external respiration, primarily of the entire respiratory volume, an improvement in the vital capacity of the lungs, the power of inhalation and exhalation, the maximum ventilation of the lungs, the reserve of respiration and absorption of oxygen in one minute. Clinical and special investigations have shown that there is considerable improvement under the influence of speleotherapy course registered in one fifth, moderate improvement in three fifths and no change in one fifth of all patients. The therapeutic effect is maintained for up to one year. This is why repeated courses 8-10 months after treatment are of prophylactic significance in regard to exacerbation of the disease and states of crisis. These states may occur under the influence of such risk factors as synoptico-meteorological, heliogeophysical, as well as of various stresses.

It should be borne in mind that the main climate-forming elements, such as solar radiation, atmospheric circulation and a variety of meteorological factors (atmospheric pressure, temperature, humidity and partial density of oxygen in the atmospheric air) are clearly of seasonal character capable at different times of giving rise to hypertonic crises, cerebral strokes, myocardial infarctions, disturbances of cardiac rhythm, and so on. Maltsev's investigations (1983) have shown that the maximum frequency of hypertonic crises and strokes is registered in the winter-spring season of the year, the minimum in summer and, vice versa, myocardial infarctions and disorders of cardiac rhythm occur more often in summer and less frequently in winter and spring.

The closest correlation has been established between the occurrence of hypertonic crises and atmospheric pressure and the passage of a cold front. The correlation coefficient between them is 0.8. A high correlative dependence has also been revealed between the character of the course of hypertonic crises and solar activity, where the correlative coefficient is 0.76.

In weather conditions which give rise to a tonic spastic effect headaches mainly localized in the parietal and occipital regions occur, attended in three fourths of all patients by increased sweating,

disturbed sleep, an authentic increase in systolic and diastolic pressure. Moreover, changes take place in the bioelectrical activity of the myocardium: the amplitude of *T* wave is reduced in left precardial leads, the *ST* segment becomes obviously displaced below the isoline while a negative *T* wave appears in the left thoracic leads. There is also a rise of the systolic index in the basin of the carotid arteries, a lower pulse filling amplitude and a higher tonus of small and medium calibre vessels. Simultaneously, vascular dystonia progresses and venous outflow becomes difficult. All these changes may cause not only a vascular crisis, but severe vascular catastrophes, as serious as stroke and acute myocardial infarction. At the same time, weather conditions (low partial density of oxygen, atmospheric pressure, temperature and vapour pressure) may give rise to a hypotensive-hypoxic effect which reduces the intensity of headaches, mainly in the temporal region. These pains are attended by general weakness, increased fatiguability, a reduction of systolic and diastolic pressure. No changes in various segments of the electrocardiogram are observed. Under such weather conditions there is a decrease in vascular tone, particularly in the basin of the carotid arteries and vertebrobasilar basins. These facts demand that the physician pay close attention to synoptico-meteorological and heliogeophysical reports and watch out for the initial intensification of clinical manifestations of cardiovascular diseases, so as to take measures in good time to prevent vascular catastrophes.

To reduce functional disorders and build up the stability of the central nervous system in patients with vascular diseases, Shkhvatsabaya et al. (1983) recommend sedatives in combination with tranquilizers and neuroleptics (glutamic acid, aminalone, nootropil or α-adrenoreceptor of pyrroxan and anticonvulsive agents) which mitigate the activity and excitability of the cortico-subcortical structures of the brain. In females suffering from premenstrual syndrome connected with the insufficient production of progesterone, a good result is produced by diuretics against a background of hypotensive neurotropic therapy. Patients with hypertensive disease connected with reflexive reactions to a sudden onset of ischaemia and cerebral hypoxia (as a consequence of vertebrobasilar or cardiac insufficiency) should be prescribed hypotonic and vasodilative drugs, most often cardiotonic agents which heighten the tone of the veins. Furthermore, before unfavourable weather conditions prevail, mental and physical tension should be reduced. If the matter concerns patients who are severely ill, in-patients or those confined to their homes, bedrest and drugs after discharge from the hospital should be prescribed. It should not be forgotten that medicoprophylactic measures should be carried out on the grounds of pathogenetic concepts forming the basis of cerebral and cardiovascular diseases in each patient individually.

Thus, the application in arterial hypertonia of natural healing factors, especially of climato- and balneotherapeutic procedures, dosaged motor activity, sea and river bathing, and physiotherapeutic factors acquires great importance both for mitigating the clinical manifestations of the hypertensive disease and particularly for preventing the progress of its various clinical forms. In cases when the character of disease development calls for the inclusion of drug therapy, the drugs must be introduced into the organism with the help of physiotherapeutic factors. To increase the efficacy of treatment it is expedient to combine such complexes with mineral baths. Repeated courses of these combinations undertaken with certain intervals considerably improve the treatment of the disease increasing the time when the patient feels well, and building up the working capacity of the patient.

Chapter 8. Physical Factors in Therapy of Patients with Arterial Hypotension

According to a decision of the scientific conference held in Vilnius in 1966, the diagnosis of arterial hypotension should be made when the stable level of arterial pressure is lower than 100/60 mm Hg for people of 25 years of age and below 105/66 mm Hg for people older than 30. The lower limit of normal systolic pressure is defined more precisely according to the formula: for males, 65 plus their age, and for females, 55 plus their age (Davis, 1974).

Chronic arterial hypotension is subdivided into primary (essential hypotension) and secondary (symptomatic hypotension). According to the statistical classification of diseases, traumas, and causes of death, which is based on the International Classification of Diseases (1980), hypotension is set apart as a nosological unit designated as the hypotension disease, that is, primary arterial hypotension.

It should be borne in mind that not only primary but secondary (symptomatic) hypotension often develops too. Most often it occurs along with several infectious diseases, particularly in brucellosis patients, as well as in certain collagenic diseases, gastric and duodenal ulcer, chronic diseases of the respiratory organs, in endocrine pathology, and so on.

Great importance in the development of the forms of hypotension is attached to the affection of the vegetative nervous system, intoxication connected with an infectious-toxic agent, and disorders of neurohumoral regulation. The hypotonic syndrome is very clearly pronounced during the active phase of the above-mentioned diseases. As the clinical course of the main disease improves, the hypotonic symptom diminishes or disappears altogether.

It is considered that primary arterial hypotension occurs most often in females from 30 to 40 years of age. Clinical observations have shown that on a level with unfavourable psychoemotional factors (such as mental overwork, acute psychic trauma, and others) of substantial significance in the development of hypotension are occupational hazards, particularly among workers employed in the chem-

ical, paint and varnish manufacturing industries, workers exposed to excess noise and vibrations in production, etc. According to Temkin (1971), 79.2 per cent of patients suffering from primary arterial hypotension are mental labourers. These patients reveal hypofunction of the sympatho-adrenal and hyperfunction of the hypophyseal-thyroid systems. In females, dysregulation of the functions of the hypophyseal-adrenal and ovarian systems is revealed. Neurohumoral disorders in the majority of patients lead to the accumulation of depressor-hypotensive metabolitogenic substances (histamine, acetylcholine, bradykinin, kallikrein, potassium and magnesium salts) which are conducive to diminishing the tonus of smooth muscles not only in vessels, but in organs of the abdominal cavity.

An important role in the condition of the tone of the smooth muscles of vessels is played by the adrenal cortex hormones: gluco- and mineralocorticoids. Research has shown that the depreciated glucocorticoid function of the adrenal cortex leads to the development of symptomatic hypotension which is one of the important clinical signs of hypocorticoidism found particularly in patients with rheumatoid arthritis, rheumatism, and other collagenic diseases. Moreover, in patients with arterial hypotension, disorders of vitamin metabolism have been ascertained, a deficit of ascorbic acid in particular, and a disturbance of electrolyte metabolism. A reduced content of sodium and a slight increase of potassium in the blood plasma have been observed.

It is important to note that all patients reveal an increased patency of peripheral vessels and a drop in general and specific peripheral resistance accompanied by an increased minute volume. This increase in minute volume to a large measure compensates for the increased patency of the precapillary vessels. The total peripheral resistance in regard to functional values decreases by 26.4 ± 1.2 per cent, on the average. It is a characteristic fact that in victims of primary arterial hypotension the depreciation of these indices is more manifest than in symptomatic hypotonia patients. Disorder of peripheral blood circulation is related to the decreased level of the tonus of the smooth muscles of arterioles and to the change in peripheral resistance. To maintain general haemodynamics and the pressure gradient, however, the tone of large vessels is heightened in compensation, and intracardiac haemodynamics improves. These mechanisms, in turn, lead to an increase by one fifth of the minute and stroke volume of blood in regard to functional values.

In their clinical course and depending on the predominance of certain symptoms, several forms and stages of primary arterial hypotension are distinguished by different authors. Obrastsova (1956), for example, sets apart the transient, labile and stable stages, as well as the cerebral, cardial and mixed forms. Rafalovich (1963) is of the opinion that hypotonic disease can be divided into three

forms: asthenic, cerebral, and cardial, and, according to the degree of compensation, into three stages: compensated, subcompensated, and decompensated.

A certain symptom complex prevails clinically, depending on these forms: in some patients the asthenic syndrome is determined, in others most prominent are complaints relating to the cardiovascular system, particularly pain in the heart region of the type of cardialgia, frequent headaches, weakness and dizziness. Pains in the heart may occur in attacks or be constant. The former are localized behind the breast bone and irradiate to the left arm and shoulder blade. The latter are concentrated near the top of the heart and are of a stabbing, aching character. In the cerebral form, fronto-parietal or temporal pains prevail.

Most patients suffer loss of working capacity and they lose interest in active life.

In patients with neurocirculatory hypotonia, there are dysfunctions not only of the cardiovascular, but of the bronchopulmonary systems. A compensatory increase in ventilation and consumption of oxygen occurs. The coefficient of oxygen consumption increases under a physical load. There is a reduction in the maximum ventilation of the lungs and in the respiration reserve, as well as a smaller increase in the minute volume of respiration. In hypotension there is a parallel, on the one hand, between the increase of the 'oxygen debt', fewer 'rest frequencies', and lengthening of the restoration period, and, on the other, the lowering of arterial pressure and main clinical signs of the disease.

It should be remembered that hypotension patients reveal stable dermographism, brittleness and greying of hair, and suffer from regional hyperhidrosis. Areas of high skin sensitivity appear on the back of the neck and on different parts of the head. The period of pain adaptation to injection in zones of hyperaesthesia is longer as compared to an indifferent area with normal sensitivity. Along with these complaints vegetative disorders are also objectively registered in hypotensive disease (hyperhidrosis or anhidrosis of the palms and feet, acrocyanosis, disorders of thermoregulation, reduced pulsation of peripheral vessels, vascular dystonias, paraesthesias in the upper and lower limbs). The level of arterial pressure and pulse are labile and depend on the position of the body and the emotional state of a patient.

The first tone is muffled at the heart apex. More rarely there is a soft systolic noise in the absence of an accent on the pulmonary artery and aorta. At times the ECG shows a decreased voltage, a reduction of the *R* and *T* waves, a lengthening of the atrioventricular interval; sometimes extrasystolia and expansion of the *QRST* complex are determined. Besides, there is an expansion of the *P* wave, a lowering, or on the contrary, a heightening of the *T* wave and

lowering of the *ST* segment. It is characteristic that in various forms of hypotensive disease there are different ECG changes, depending on the degree of trophic disorders of the myocardium.

The minute volume of the heart in these patients is heightened. According to Gembitsky, the volume of circulating blood in hypotensive disease is equal to 81.8 ml per kilogram of body weight (the normal index is 70-90 ml per kilogram of body weight). The rate of blood flow in hypotensive patients is within normal limits.

Since the clinical manifestations of primary arterial hypotension are so varied, in each case the character and degree of the registered disorders to a great measure determine therapeutic tactics. Combined remedial measures must be prescribed strictly individually and carried out primarily during the early stage of the disease.

In neuroses with a prevalence of the excitation process in patients suffering from primary arterial hypotension, both sedatives and invigorating agents (seduxen, elenium, extract of valerianae, arsenical derivatives) should be prescribed. If the process of inhibition predominates, it is best to use tonics and generally invigorating agents (caffeine, securinine, phenamine, pantocrine, tinctures of ginseng and lemon, etc.). For marked weakness, apathy and a considerable drop in arterial pressure it is recommended to prescribe potent agents which increase the tonus of vessels (norepinephrine, ephedrine, phenylephrine hydrochloride or their combination with cortisone, prednisolone, mineralocorticoids—desoxycorticosterone).

Drugs are prescribed differently for individual patients in the general complex of therapeutic measures. A prominent place in the complex is alloted to a well-planned diet, which should comprise full-value foods with a predominance of animal proteins plus a large quantity of vitamins, particularly vitamin C and vitamins of the B group.

Spa treatment for patients suffering from arterial hypotonia includes various elements of combined therapy, namely: (1) motor activity and therapeutic training exercises, (2) climatotherapy, (3) balneotherapy, (4) physiotherapy, (5) diet, (6) psychotherapy.

The motor regimen for such patients must be active. If the patient suffers from frequent headaches and pain in the region of the heart, it is expedient to prescribe moderate physical loads. Patients with frequent spells of dizziness and dyspnoea should be given smaller physical loads with subsequent transfer to moderate physical exertion. Moreover, hygienic physical training exercises must be conducted regularly to train the body and help the organism to arouse from night-time sleep to wakeful activity. If cardiac activity is flaccid, the respiratory load should be increased.

The highest pressor effect is produced by strength exercises conducted at a moderate rate to activate large muscle groups, exercises developing speed and strength, and static tension exercises.

In treating patients with hypotension disease wide use should be made of climatic factors, prescribing aerotherapy, sleep in the open air, dosaged sea bathing. All climatic procedures must be dosaged and the general condition of the patient considered, as well as the functional state of the nervous system, age, a susceptibility to common colds. If the procedure is poorly tolerated (chills, headaches, palpitation, bad sleep) it should be discontinued. The best place for treatment by climatic factors is a special climatic pavilion. Sleep on the seashore acquires important significance. It helps to improve the function of external respiration, to stimulate redox processes, and makes the patient feel better.

Air baths have a multiple effect on the organism by temperature, humidity, movement of the air and solar radiation. The lower the temperature, the greater the effect of the bath. The best time for air baths is from ten in the morning to one o'clock in the afternoon and from five to seven in the evening. Heliotherapy is measured in calories or by the erythema reaction of the skin; a biodose comprises the amount of ultraviolet radiation causing the development of the first stage erythema on the skin. Erythema is determined by means of a biodosimeter; one biodose is equivalent to 20 calories.

Sea baths train the mechanisms of thermoregulation and normalization of metabolic processes; they heighten the vascular tonus and harden the body. It is recommended to conduct sea bathing when the temperature of the water is not lower than 17 °C, and the sea-wave is no higher than three points, while the temperature of the air is not lower than 19 °C. The baths should last from 3 to 10 minutes, depending on how the patient tolerates bathing procedures.

The best result in the combined treatment of primary arterial hypotension can be achieved by the prescription of radon baths (radon concentration 20, 40, 80 nanocurie/l) at a temperature of 35-36 °C, 12 to 15 minutes long, conducted every other day for a course of 12-14 procedures. Also effective are nitrogen-radon, chloride-sodium baths, and in certain forms of hypotension, particularly when the process of excitation prevails—iodobromine baths. When hypotension develops against a background of neurosis with a predominant inhibition process and cardiac manifestations, it is expedient to make use of CO_2 baths at a temperature of 33-34 °C, lasting 6-8 minutes every other day, for a course of 10-12 baths. The course of balneotherapy should be combined with motor activity. In the persistent development of hypotension, these baths are prescribed on a level with drug electrophoresis, primarily sodium electrophoresis which should be conducted 90-120 minutes prior to physical training exercises and the taking of mineral baths. The electrodes are placed on the region of adrenals. Sodium is infused at the positive pole in a 5 per cent saline solution and a current density of 0.5 mA/cm^2, the procedure lasts 15 minutes for a course of 14-16 procedures. If

correctly chosen, combined treatment by physical factors, mineral baths combined with terrain-cure motor activity, air baths, and physical training exercises prescribed in line with adequate methods, is sure to be successful.

Caffeine electrophoresis after Vermel is of paramount importance in combined treatment. The active electrode with a 15 × 20 cm pad is placed onto the interscapular region. Two other electrodes with 10 × 15 cm pads are attached to the back surfaces of the crura. The strength of current is 10-20 mA, the procedures are 20 minutes long and are conducted daily or every other day. Ionophoresis with calcium by Shcherbak's method is very effective; the strength of current 6 mA, length of procedure 6 minutes with an increase of 2 mA for each successive procedure to a maximum of 16 mA and length of procedures increasing to 16 minutes. The course of treatment includes up to 12 procedures.

A good effect is produced by foot baths before going to bed at night at a temperature of 35-36 °C for 20 minutes, as well as moist rubdowns.

All these procedures should be combined with psychotherapy. The psychotherapist must conduct several talks with his patients, explaining that the subjective condition is only imaginary. When psychotherapy fails to produce the desired effect, hypnosis is indicated.

Chapter 9. Healing Effect of Physical Factors on Obliterating Diseases of Great Arteries

Obliterating lesions of the peripheral arteries of the limbs include two pathological groups: obliterating endarteritis and atherosclerotic occlusions of the main arteries of the limbs. Clinically, however, these forms are often covered by the term 'obliterating diseases of the peripheral arteries of the limbs' because of their common symptoms, principles of diagnostics and treatment.

The distinction between these two diseases, however, is not only of theoretical, but of practical significance. Obliterating endarteritis is a disease of the young and middle age. The most marked changes occur in the main peripheral arteries, and the vessels are affected not along their entire length, but in segments and mostly in the distal parts, the shin and the foot. Obliterating atherosclerosis of the limb vessels is a disease of elderly patients, in which the changes are of a more general character and occur mostly in the larger arteries.

Obliterating endarteritis is a polyaetiological disease. It may be caused by infections which are accompanied by an allergic component, prolonged exposure to cold, particularly that which results in frostbite or childblain, frequent repetition of drops in arterial pressure, negative emotions causing vascular spasms, smoking. This may occur because of a genetic predisposition or an acquired lability of vessels with the predomination of vasoconstrictive reactions. In many patients the disease is caused not just by one of these factors, but by several acting simultaneously.

Atherosclerotic occlusions of the main arteries of the limbs are closely connected to the development of general and atherosclerosis of organs.

Some researchers claim that the age of patients may serve to differentiate these diseases; to be more precise, elderly patients are more likely to suffer from an atherosclerotic lesion than from obliterating endarteritis. The localization of the process is also of differential-diagnostic significance. Both feet are affected more often in atherosclerosis than in endarteritis. In atherosclerosis of the lower limbs, the tendency to thrombophlebites or migrating phlebites is seen less frequently than in endarteritis. In atherosclerotic affection

of the vessels of the limbs disorders of peripheral circulation develop gradually, and the organism usually has time to adapt to new conditions. In obliterating endarteritis against a background of a chronic course of the disease, there are frequent exacerbations, the main process is complicated by thrombophlebitis, and inflammatory phenomena are more marked. All this reduces the possibilities of the organism to compensate for the disturbed functions of peripheral circulation.

Various pathogenetic links participate in the development of obliterating and occlusive diseases of the peripheral arteries of the limbs. In each case these links must be defined so as to evaluate the clinical features of the disease and correctly choose the most effective therapeutic measures. A major role in the development of these diseases is played by the nervous system, disorders of which become the main link originating the neurodystrophic process in the vascular wall.

Dissociation of the functions of different links of the central nervous system is the cause of not only neurodystrophy, but produces a telling effect on the activity of the sympatho-adrenal and hypothalamo-hypophyseal-adrenal systems.

The blood vessels of the limbs are innervated by sympathetic nerve fibres where the mediator is, for the most part, norepinephrine. In view of this it may be presumed that any harmful factors (such as cold, smoking, mechanical and psychic traumas, etc.) which lead to the development of an abnormal process in the vascular wall are accomplished by means of the adrenergic nerves and their mediator norepinephrine. In patients with obliterating vascular diseases of the lower limbs, there is a certain increase in the amount of free norepinephrine, which results in a spasm and disturbance of the trophics of the vascular wall. Sharp fluctuations in the level of norepinephrine in such patients are evidence of the dysfunction of the sympathetic part of the vegetative nervous system.

The main point in the pathogenesis of obliterating endarteritis is the vascular spasm. In the developmental mechanism which effects the transition of the spastic (functional) stage to the stage of morphological changes of vessels, importance is attached to ischaemia of the vascular wall, allergy, and disturbance of nervous trophics. The intensification of the vascular spasm, particularly of the arterioles, precapillaries, and capillaries, decreases the blood supply to the tissues, which is conducive to intracellular hypoxia, accumulation of vasoactive, metabolitogenic, hypertensive substances which aggravate the processes mentioned. The contractile ability of the capillaries is sharply curtailed; the data of capillaroscopy shows that the capillaries become smaller, the transitional bend expands somewhat; their branches, as a rule, are dim or not visible at all, they are convoluted or assume a cubic shape.

According to the oscillograms recorded in investigating limbs at different stages, the investigator can determine the place of the relatively high oscillatory index, i.e. practically the place where the vessel narrows, the thrombus. Below this level the oscillatory index sharply decreases, because the blood begins flowing along the collaterals. In obliterating endarteritis there is a shorter amplitude of oscillations and a depreciation of the oscillatory index primarily in the dorsal arteries of the feet. As the process advances, the index as registered in the shin decreases too. These data correspond to the clinically defined localization of the process. In obliterating atherosclerosis in the region of the iliac or femoral segment, changes in the oscillogram occur mainly in the proximal parts of the limbs. With the advance of the disease, deep hypoxic phenomena develop due to which the redox processes in the tissues deteriorate, neurodystrophic processes increase and disorders in cellular metabolism occur both in the vascular wall and in the tissues of the limb. Epshtein, Vinnitskaya, Maksimova and Zolotorevsky (1969) demonstrated that the rate of oxygen consumption by the tissues, especially by the muscles which are affected by the obliterating process in the limb, is lower than normal. Oxygen tension (pressure) (PO_2) in the tissues of these patients is low. When an 'exsanguination' test of the affected limb is made (by raising the limb and applying a tourniquet), a paradoxical slower rate of PO_2 level drop develops. These phenomena are observed both in compensated and subcompensated forms of obliterating diseases. A slower rate of oxygen consumption is regarded to be a compensatory-adaptive process related to the reconstruction of the metabolic and particularly the oxidative function of the tissues, which occurs over the long course of the obliterating process. These changes in cellular metabolism mount until the adaptive mechanisms are disrupted, which in the long run leads to a necrotic process.

Alongside with vascular changes in patients suffering from obliterating diseases of the peripheral arteries, a hypercoagulative syndrome develops, accelerating the progress of the disease and the emergence of various complications. Special investigations have shown that fibrinolytic activity is steadily inhibited and changes tending to hypercoagulation develop, particularly evident in such indices as fibrinogen, free heparin, etc. Blood antiplasmins, on the contrary, decrease. It is fairly possible that in developing hypercoagulation there is a compensatory reduction in blood antiplasmins, which to some measure causes the compensatory intensification of fibrinolytic activity. It is a matter of record that the activation of fibrinolysis takes place when blood antiplasmins reach a certain minimum level.

Obliterating atherosclerosis is principally distinguished from obliterating endarteritis in the following way: in the atherosclerotic

process it is the large veins of the illiofemoral and the femoropopliteal segments which are affected, whereas in obliterating endarteritis and migrating thromboangiitis*, on the contrary, the process is inflammatory and begins with diffuse affection of the capillaries, arterioles and arterial branches. At first thrombosis of the arterioles and arteries of the feet and shin develops, and then, as the process intensifies, it spreads to the larger main arteries (ascending thrombosis). In atherosclerotic occlusions the smaller arteries of the foot and shin are affected a second time. In this form the patency of the arteries is completely disturbed. Obstruction after the occurrence of local occlusion develops more often because of thrombosis of the arteries along their length. The inflammatory proliferative process in inflammatory diseases is manifested in the form of tiny cellular infiltrates and leads to the destruction of the collagenic structure of connective tissue, the development of fibrinoid necrosis of the vascular wall, which is clinically manifested by ascending arteritis and thrombophlebitis.

In obliterating endarteritis and thromboangiitis the intima thickens mainly at the expense of the inflammatory hyperplastic process of the subendothelial and subintimal tissue, whereas in atherosclerotic occlusion the intima thickens unevenly as a result of the development of atheromatous patches containing cholesterol, lipids and very often calcium salts. Moreover, in atherosclerosis, fibrosis of the paravasal tissue is not defined clinically. This process develops most often in thromboangiitis and endarteritis. The atherosclerotic occlusive process develops clinically more favourably before the development of necrosis than arteritis and thromboangiitis which have progressive and generalized course from the very start of the disease. In generalization of the process the migrating thrombi may affect the cerebral vessels, the vessels of the eye fundus, and result in very severe consequences.

In each of the clinical forms of these diseases (obliterating endarteritis, thromboangiitis and atherosclerotic occlusions of the main arteries), there are three stages of development: the first is the early stage of the disease or the stage of compensated blood circulation characterized by chilblain in the feet, paraesthesia in the form of 'gooseflesh', a prickly sensation in the big toe, hyper- or anhidrosis, a low temperature of the limb, hair loss, particularly on the outer surface of the shin, paleness of skin, slight cyanosis, a weak pulse in the arteries of the feet, and a decrease of rheographic indices, which is a signal of the lesser blood filling of the limbs. After certain physical exertion, the lower limbs become tired. It should be borne in mind that at the early stage the diagnosis is somewhat difficult,

* A variant of obliterating endarteritis, in which the process begins with the lesion of small peripheral veins of the limbs, or peripheral arteries with a transition to the veins.

particularly if the patient is simultaneously suffering from platypodia, small phlebectases, initial stages of the diseases of joints, intervertebral osteochondrosis and diseases of the peripheral nerves.

The second stage, i, e. the stage of marked clinical manifestations of the disease, is characterized by tiredness in the legs and feet even under the slightest physical exertion, intermittent limping, a feeling of cold particularly in the toes and the region of the heel. Due to developing ischaemia and dystrophic changes, there are aching pains or short stabs of pain connected with hypoxia or ascending ischaemic neuritis, more often of the minor fibular nerve. Moreover, fungal lesions of the nails and skin may develop. Considerable changes in the colour of the skin of limbs, trophic changes, hypo- and anhidrosis, a weakening or absence of pulse on the dorsal and posterior fibular arteries are clinically determined. The rheographic curve changes drastically: a sharp drop in the rheographic index, a marked vascular plateau, the peaks of the pulse wave are smoothed over, the period of the anacrotic rise is prolonged, arterial pressure is also reduced in the arteries of the shin, most often by 20-25 mm Hg as compared to normal. At the same time the physician finds that if the gastrocnemius muscle of the patient is quickly grasped and pressed, sharp pain is felt along the length of the fibular arteries. It should be emphasized that at this stage patients with atherosclerotic occlusions feel much better than at the same stage of obliterating endarteritis.

The third stage is a period of trophic disorders, or the pregangrenous stage characterized by a considerable deficiency of circulation and developing dystrophy of the tissues of the affected limb. Patients complain of constant pains in the limb, which intensify at night, of marked intermittent limping, chills and severe paraesthesias. Pulsation in the main arteries is barely determined, the skin is greatly changed and is of a purplish cyanotic hue; in occlusion the colour is sharply pale with a yellowish shade. There are cracks and small ulcers on the toes. The rheographic index is sharply depressed, at times to zero. Chronic venous insufficiency is aggravated against this background, which during the first stage is of positive significance, because it causes passive hyperaemia and improves the nutrition of tissues. Later, however, venous insufficiency joins the arterial insufficiency and the clinical course of the disease deteriorates. In all forms of vascular diseases with the impairment of patency of the main arteries, the collaterals develop and at certain stages of the disease prevent necrosis of the limbs.

The principles of combined spa treatment for patients with obliterating diseases of the peripheral vessels are based on a differential approach to the use of mineral waters, healing muds, physiotherapeutic procedures, dosaged motor activity depending on the clinical forms and stages of these diseases. The more intensive the clinical

course of the obliterating process and the more marked the disturbances of blood supply to the distal part of the limb, the more sparing should be the methods for applying physical factors (low concentrations of macroelements of mineral waters with lesser content of sulphides and radon, a weaker intensity of physiotherapeutic factors, smaller doses of motor activity, climatotherapeutic procedures, and so forth). All procedures must be conducted with caution to avoid trauma to the limb. Every trauma, small as it may be, may bring about an exacerbation of the process and become conducive to the development of necrosis in the dystrophically changed tissues. The methods for applying therapeutic complexes must be planned with proper consideration for local changes in circulation, the state of trophic processes and also of general and local reactivity.

In prescribing combined treatment for such patients, one must proceed not only from the character of changes in peripheral circulation but from the degree of disorders in coronary and cerebral circulation, the spread of circulatory disorders to the organs of thoracic and abdominal cavities, which may be determined by clinical and rheographic indices. Vasodilative and spasmolytic agents may be included in the therapeutic complex where necessary (angiotrophin, padutin, depot-padutin, bupatol, mydocalm). The main effect of these drugs lies in their ability to reduce the excitability of vegetative ganglia, which dilates the peripheral vessels and alleviates pain. It is also expedient to make use of the spasmolytic agent nospanum. These drugs, however, have a therapeutic effect mainly in patients at the early stage of the disease, at the time of spastic disorders of capillary circulation.

The method of applying spa factors should be appropriate to the functional changes in the neurovascular system and aimed at enhancing trophic processes by intensifying the adaptive-trophic function of the sympathetic nervous system and by increasing vasoactive substances which help to reduce or remove vascular spasms, stimulate cellular metabolism and develop the collateral network.

Patients with first and second stage obliterating endarteritis and atherosclerotic occlusions should be given sulphide baths with a hydrogen sulphide content of 100-150 mg/l, radon baths with a radon concentration of 20-30 nanocurie/l, carbon dioxide-sulphide and nitrogen-radon baths at a temperature of 35-37 °C lasting 10-15 minutes, two days in succession with a day of respite, for a course of 12-14 procedures. In the first stage thromboangiitis small local baths are most effective. Since in the second stage of thromboangiitis there are frequent exacerbations of the process, it would be a good thing to include microwave therapy in the therapeutic complex, extrafocal sinusoidal modulated currents, sulphide or radon local baths for the affected limb. Subsequently, as the process subsides, these procedures may be alternated with common carbon dioxide-

sulphide, sulphide, nitrogen-radon or iodobromine baths (microwave therapy on the first day, and on the second, one of these types of baths by the nonintensive method). If there are unfavourable reactions in some patients, certain modifications should be introduced: the concentration of the basic components of waters should be reduced, the temperature of baths lowered and the procedures shortened along with their frequency.

The concentration of hydrogen sulphide is reduced from 150 to 100 mg/l or from 75 to 50 mg/l and of radon from 40 to 20 nanocurie/l. The temperature is lowered to 35 °C and the procedures shortened to 7 or even 5 minutes. Moreover, in such instances electric treatment may be included in the therapeutic complex: microwave therapy, pulse magnetic field, lidocaine- or pirilene-electrophoresis, as well as novocaine blocks. Within 7-10 days after these alterations have been implemented an improvement usually occurs: pain subsides, chilblain and intermittent limping decrease. The capillaroscopic picture reveals a reduction or complete disappearance of the dim background, a pink background appears instead; the arterial branches expand. Furthermore, the skin temperature of the limb increases (by 0.5-1.5 °C) as compared to the initial state. There are fewer dystrophic changes in the tissues (especially 2-3 months after the course of treatment). The endurance of the limb to physical loads increases. These positive shifts are the result of complicated changes occurring in the organism of patients under the influence of combined treatment by physical factors. Each of the mentioned balneotherapeutic factors produces a specific effect on the organism and at the same time renders a general non-specific influence. The movement of blood from the internal organs to the skin and main vessels of the limbs while taking mineral baths, and also the removal of the reflexive spasm under their influence improve the blood supply to the affected limb. On a level with these changes, biologically active substances causing vasodilation appear under the effect of radon and sulphide baths. This is conducive to the expansion of arterioles and precapillaries, the development of collaterals, improved transportation of formative and energy materials, the weakening of hypoxia and improvement of redox processes, as well as the stimulation of metabolism and evacuation of metabolites from the body.

The intensification of these processes improves the health of the patient: there are less neurotic reactions, sleep improves, the endurance of tissues to loads increases, working capacity grows. These positive changes, however, are usually maintained for only 6-8 months, and then the attained effect wears down and the clinical manifestations of vascular disturbances reappear. For the purpose of secondary prophylaxis, it is recommended to conduct a course of physiotherapeutic procedures four to five months after the course of balneotherapy.

Akulova and Nikolaeva (1971) showed that microwave therapy (12.6 cm wavelength) of warm and heated intensity, applied to the region of lumbar sympathetic nodes and the neurovascular bundle of femurs, renders a positive influence over the clinical course of the disease, improving local and general haemodynamics. Microwave therapy of weak intensity (30 watts) by the method mentioned leads to more substantial positive changes in local haemodynamics than similar procedures of greater intensity (45-60 watts).

In atherosclerotic occlusions, obliterating endarteritis, particularly of the second and third stages, mineral baths must be combined with oxygen therapy, with the prescription of oxygen tent, for example. A tent is set up over the bath and oxygen is piped in. The patient thus undergoes two procedures: a sulphide or radon bath and oxygen inhalation. The saturation of tissues with oxygen against the background of the above-mentioned specific and non-specific effect of balneotherapy produces a very favourable healing effect. A course of these procedures in combination with physical training exercises and segmentary reflexive massage of the lumbar region and the dorsal surface of femurs, and dosaged motor activity considerably improves local circulation, tissue trophics, increases the blood supply of nerve trunks in the limbs and reduces ischaemic pain connected with ascending neuritis. As a result of better cardiohaemodynamics, decrease of hypoxia, and enhanced metabolism in the myocardium, pain in the region of the heart alleviates or disappears. At the same time the functions of digestion and excretion return to normal.

In the third stage of obliterating diseases of the limbs when dystrophic changes are at the start of the gangrenous phase (cracks and ulcers appear, ischaemic neuritis mounts), two- or four-cell baths for the limbs should be prescribed or mud applications on the lumbar region. It is expedient to conduct magnetotherapy with the Polus-1 apparatus at an intensity of 150-200 oersteds, 10-12 minutes for a course of 16-20 procedures.

Clinical observations show that such an approach to balneo- and mud therapy, particularly when the prescribed procedures are not conducted at very high temperatures (baths 35-36 °C, mud applications 38-40 °C) and are of moderate length, yields good results, while the frequency of exacerbations decreases. During the gangrenous process balneo- and mud therapy are contraindicated.

Repeated courses of treatment, not only under spa conditions but at home and at clinics with the use of physiotherapeutic procedures, drugs, artificial mineral waters, physical training exercises and massage, help to stabilize the results and slow down the advance of the disease.

Chapter 10. Physical Factors in Therapy and Rehabilitation of Patients with Chronic Venous Insufficiency of the Lower Extremities

Chronic venous insufficiency of the lower extremities usually occurs due to varicosis, thrombosis, various injuries of the neurovascular bundle or certain areas of the body, resulting in various degrees of vascular impairment.

Clinical observations and special studies show that venous diseases occur not only as local disorders of an affected vascular segment, but also as substantial circulatory disorders in the extremities, dystrophic changes amounting to trophic ulcers, and locomotor dysfunction.

When planning therapy, aetiologic and pathogenetic factors of each manifestation of the disease must be considered, since a lack of this knowledge, or ignoring these factors, may lead to complications and severe consequences. Evaluating anamnestic findings, the clinician must first elucidate the basis of the vascular disease and the pathogenetic mechanisms responsible for its clinical manifestations. The analysis of these factors requires a brief review of aetiologic and pathogenetic concepts of different clinical forms of venous disease resulting in chronic venous insufficiency, and of major diagnostic criteria and therapeutic methods.

Chronic Venous Insufficiency due to Varicosis

Varicosis of the lower extremities is a very common affection. Its causes are: genetically determined weakness of the muscular elastic fibres of superficial vein walls; impairment of the valvular system; and a history of toxic infectious diseases. Varicosis of pregnancy is considered separately, since it is hormone-mediated and associated with congenital properties of the venous muscular wall. According to Naarits (1961) and Nikolaenkova (1966), the smooth muscle tone, including that of the walls of leg veins, is affected by corpus luteum hormones during pregnancy.

The mentioned factors are only predisposing ones since they determine the anatomic and functional impairment of superficial leg

veins. As intravascular pressure increases, the vein with the impaired muscular elastic wall layer fails to change its tone, and irreversible dilation of the venous lumen occurs. The pressure in superficial leg veins may increase because of impeded blood outflow, regurgitation of blood from deep veins into superficial ones and from the arterial system into the venous via arteriolar-venular shunts. Blood congestion primarily affects the superficial veins; the deep veins located in musculofascial layers are more resistant to increased intravascular pressure. Because of superficial vein dilation, the cusps of veins separate, and their gate function is impaired. This results in greater hydrostatic pressure and greater blood gravity against venous walls. Retrograde blood flow (reflux) and venous congestion occur resulting in chronic venous insufficiency.

The Troyanov-Trendelenburg test is of great value in the identification of valvular insufficiency of the greater and lesser subcutaneous veins and of retrograde blood flow. The patient is made recumbent, and his/her leg is held up until subcutaneous veins are drained (as observed visually). The greater subcutaneous vein below the groin fold is squeezed against the underlying tissues with a tourniquet or fingers. Then the patient is placed in an upright position, and the venous filling is observed. A rapid downward filling of the vein after the tourniquet is removed indicates functional insufficiency of subcutaneous vein valves. If the vein with a tourniquet applied is rapidly filled upward in the erect patient and the filling is not increased by tourniquet removal, then insufficiency of communicating veins and normal valvular function of the greater subcutaneous vein are implied.

The Hackenbruch-Séquard test is used to evaluate the valvular performance of great deep and subcutaneous veins. The reclining patient is asked to cough. A beat detected by the examiner's hand in the median third of the thigh is indicative of valvular insufficiency of deep veins. In the case of valvular insufficiency of the lesser subcutaneous vein, the beat is felt in the popliteal area.

The Mayo-Pratt test, the Delbet-Perthes walking test and the Strelnikov test are used to evaluate the patency and function of deep veins. For the Mayo-Pratt test the tourniquet is applied to the upper thigh of the recumbent patient, and the leg is dressed with an elastic bandage from the toes to the upper thigh. The patient is instructed to walk for 20-25 minutes. Swelling pain in the shin area indicates impaired patency of deep veins. The Delbet-Perthes test requires squeezing with a tourniquet the subcutaneous vein of the upper thigh in the standing patient. The patient is asked to walk for 5-10 minutes. The emptying of varicated shin veins suggests normal valvular function of deep veins. However, varices which remain to be filled after walking may indicate marked insufficiency of perforating vein valves. The so-called five-tourniquet test is

used in differential diagnosis: tourniquets are applied to the upper and median thigh and to the upper, median, and lower thirds of the shin. Emptying of varices after walking, seen at least in one of the tourniquet interspaces, suggests normal functioning of deep vein valves. Tense varices are indicative of valvular malfunction of perforating veins.

In the Strelnikov test, a cuff is applied to the patient's thigh or shin (while in the standing position), and 30-40 mm Hg pressure is induced, making the superficial veins swell. The patient is then placed in a horizontal position. The emptying of superficial veins in this position indicates the patency of deep veins.

Comparison of test results and clinical and phlebographic findings enables an accurate evaluation of the disease process, and consequently, an appropriate choice of therapy with natural and transformed physical factors.

Varicosis involving only superficial veins precludes chronic venous insufficiency. Chronic venous insufficiency may be subcompensated or decompensated in varicosis involving both superficial and perforating veins, and in varicosis affecting each of the three systems: superficial, perforating, and deep veins. Trophic skin conditions amounting to trophic varicose ulcers may be found during decompensated stage.

Thrombosis-Associated Chronic Venous Insufficiency of the Lower Extremities

Varicosis is complicated by thrombophlebitis and phlebothrombosis in a significant number of patients. These diseases are induced by altered reactivity, neurotrophic and endocrine disorders, and enhanced levels of coagulation factors. A common triggering factor is infection which causes hypersensitization, modification of immune responsiveness, and abnormal biochemical blood composition.

Studies by Kolesnikova and Zaidenberg on mucopolysaccharide (glycosaminoglycan) and sialic acid levels in venous blood plasma and cellular constituents of the venous wall reveal immunopathologic abnormalities in patients with varicosis, occurring in altered systemic and local reactivity.

Thrombophlebitis is the inflammation of the venous wall (phlebitis) and thrombosis of it. Inflammation of an internal venous layer (endophlebitis) occurs first and is followed by thrombosis; occasionally the process occurs vice versa. Abnormal relationships between the blood and the vascular wall, such as sluggish or turbulent blood flow, disorders of the vessel wall and abnormal blood chemistries play a great role in the mechanism of thrombosis. Thrombosis is induced by infectious inflammatory processes in varicose veins. The inflammatory process may expand over the vein from the adjacent tissue and

cause thrombosis of the vessel (perithrombophlebitis). A thrombus may be initially produced in the venous lumen with subsequent inflammation of the venous wall (endophlebitis).

In contrast to thrombophlebitis, phlebothrombosis commonly occurs without inflammatory symptoms and, not infrequently, is diagnosed only at the onset of embolism of pulmonary or other great vessels, produced by a dislodged piece of a loose clot poorly adhering to the venous wall. Like in phlebothrombosis, clot formation in thrombophlebitis is associated with multiple disorders of the coagulation and fibrinolytic blood systems and with inhibition of fibrinolysis.

Thrombophlebitis is clinically classified as acute, subacute, or chronic. Thrombophlebitis of superficial leg veins is more common than that of deep ones. Acute thrombophlebitis of deep leg veins has a very rapid onset (within hours). It is often a postpartum complication. Acute pain is experienced along the affected vessel and leg oedema develops. The leg becomes pallid and cold, sometimes cyanotic. The body temperature increases to 39-40 °C. Acute superficial thrombophlebitis also causes acute pain along the clotted vein, although leg oedema is milder. The clotted vein may feel like a hard band; groin lymph nodes are enlarged, there is a fever. Acute thrombophlebitis of both superficial and deep veins may become subacute and chronic. Chronic deep vein thrombophlebitis may have a very protracted, frequently relapsing course. Symptoms (oedema and pain) are not prominent and tend to worsen by evening; they usually disappear after the night sleep. Gastrocnemius muscles and the femoral vascular bundle may be painful on palpation.

Chronic venous insufficiency may be caused by thrombosis which is not accompanied by venous wall inflammation. Thrombosis is common in immune impairment due to protracted torpid infections. Apart from haematologic disorders (lowered platelet resistance, common elevations of platelet and leukocyte counts and globulin and fibrinogen levels) and acidotic changes, altered properties of venous wall endothelium and torpid blood flow are also important. These alterations lead to the formation and lodging of a clot: clots can be of variable structure and nature. Thus 'red' clots, which are loosely bound to the vessel wall and relatively soft, are dangerous since they can be readily torn away and cause an embolism.

Very soon after the onset of acute thrombosis, the coagulation factors cause retraction of the clot which begins to be lysed by fibrinolysin. The clots shrink and hence are reduced in size. Further changes of the clots consist of softening and their penetration by connective tissue (within six to eight months after the onset of thrombosis) which occurs as the young connective tissue of the vessel wall grows into the clots. The clot is invaded by cellular elements like fibro-

blasts; the endothelium of the clot-adjacent vessel grows over the clot surface, sometimes covering it. In the process of clot shrinkage, cavities appear within the clot, and those communicating it with the vascular wall. These are lined with endothelium filled with blood, and serve to restore circulation in a given vessel, i.e. clot canalization takes place. Within eight to twelve months (or later), after the onset of acute thrombosis, marked phlebosclerosis is found in all layers of the vascular wall, with atrophy and necrobiosis predominant in the smooth muscles and elastic fibres of the vascular wall and with its tissue architectonics impaired.

Frequently, partial or complete obliteration of the vascular lumen with fibrous connective tissues, clot calcinosis, induration of the venous wall and irreversible destruction of valves occur. Detached from the venous wall, the calcinated clots remain in the vascular lumen as vein stones (phleboliths); they are especially common in varicose veins. In some patients, great vein occlusion occurs, severely affecting the blood flow. It has been experimentally demonstrated by Grigoryan (1979) that a month and a half after the onset of thrombosis collaterals appear, and their numbers and diameters are increasingly greater. After five-six months there appear anastomoses communicating great veins by circumventing the clotted site. These changes help increase the venous outflow via the collateral system resulting in milder venous hypertension. The resultant reflexive spasticity of counterpart arteries causes a reduction in arterial blood flow to the distal extremity. On the other hand, metabolite elimination from the distal extremity improves because of compensatory dilation of lymphatic collectors. These are mechanisms of circulatory self-regulation which is determined by compensatory potentials of the vascular wall, location and duration of the occlusion, pattern of clot changes, and canalization of it.

It should be borne in mind that thrombosis often occurs during pregnancy and postpartum. Thrombosis occurs predominantly in great shin veins during pregnancy, whereas it is more common in pelvic and femoral veins in the postpartum period. Furthermore, the disease is clinicodiagnostically classified as thrombosis of the femoral-iliac segment, of the femoral vein (above the opening of the deep femoral vein), or thrombosis of the popliteal-femoral segment. The location and initial manifestations of thrombosis play a role in the clinical course of chronic venous insufficiency. During the chronic phase patients complain of dull pain in the lumbosacral spinal segment and lower abdomen; the pain is probably due to a circulatory impairment in the small pelvis related to a history of thrombosis or hypertensive venous segment, or involvement of neural elements of the vascular wall. Apart from pain and oedema, leg paleness and subsequent cyanosis occur; the affected leg has a lower vascular pulsation because of reflex arterial spasticity.

Clinical Characteristics of Various Types of Chronic Venous Insufficiency

Chronic venous insufficiency is manifested to different degrees. The comprehensive evaluation of clinicophysiological findings in patients with chronic venous insufficiency of any aetiology suggests three stages of it (classification of Kolesnikova, 1968): compensated, subcompensated, and decompensated.

Symptoms of compensated disease are rather scarce. Except for the sensation of heaviness in the limb and varices, no clinical symptoms are found. Capillaroscopy shows solitary congestive capillaries, oscillography suggests spasticity of great arteries, rheography indicates blood depletion in the leg.

The skin temperature is increased at varicose sites and decreased in the toes.

The subcompensated stage presents itself as oedema of the leg, particularly its distal segment, greater pain, and a sensation of heaviness and swelling in the affected limb. All haemodynamic abnormalities are more marked. As the disease evolves and passes into the decompensated stage, dysregulation of capillary haemodynamics and arterial reflux into the venous system via arteriolar-venular shunts cause cellular hypoxia in the distal leg, abnormality of tissue metabolism, and worsening of the general condition of the patient. Peripheral circulatory disorders are aggravated. Oedema, induration, varicosis and dystrophic changes of the skin occur. Ischaemic pain often becomes vegetative and is experienced as burning, cutting or drilling pain in the affected limb. Elevations of skin temperature are also common: even in canalization of a deep vein clot, it is 3-5 °C higher than the temperature of the normal leg. Perhaps it is related to the fact that deep vein hypertension causes the venous blood to come to subcutaneous veins via communicating veins, and, as is known, the temperature of deep vein blood is higher than that of subcutaneous.

The neurovascular vegetative disorders lead to cutaneous thermal asymmetry because of a dissociation of thermoregulation resulting in greater heat production and lesser heat emission. These abnormalities are determined by a newer level of cellular metabolism induced by morphologic and functional abnormalities resulting from venous insufficiency.

Rheographic findings indicate alterations in the blood supply of the affected extremity. The patients have an increased β index: the ratio of the regression period of the rheographic wave to the rheographic reading multiplied by the heart rate is increased 4-6 times.

Functional rheography shows secondary respiratory waves and a climbing of the rheographic curve during forced respiration and

Valsalva manoeuvre; oxygen delivery to the tissues is reduced and redox processes are impaired.

Since patients develop variably manifest trophic disorders, the disease at this stage is differentiated into three forms: oedematous, indurative and dystrophic, or ulcerative. Apart from the mentioned abnormalities, the oedematous form is characterized by the onset of oedema due to lymph and blood circulatory disorders. In the indurative form, blood outflow and tissue trophism are further impaired by the outgrowth of connective tissue and the replacement of the adipose tissue by fibrous one expanding over considerable areas of the extremity. The allergic component plays an important role in the development of this form of the disease. Protein released from the injured wall of the vein into the intercellular space and the onset of an endogenous infection lead to sensitization and allergic reactions which clinically present themselves as new oedematous sites, fibrous induration of soft tissues and trophic impairment, dermatitis and eczema. As this process advances either a dystrophic, or an ulcerative form of the disease develops, differing from the aforementioned in that it occurs because of severe local circulatory disorders and metabolic abnormalities which are followed by productive inflammation and neurodystrophic disorders. The appearance of a varicose ulcer is often interpreted as a sequela to the neurodystrophic process and lowered resistance of the affected soft tissues. The ulcer is commonly located on the inner shin, above the ankle, and seldom on the frontal or outer surface of the lower shin. Regional hypertension commonly occurring due to valvular insufficiency of communicating and deep veins is also an important factor in the ulcerative process. A wide communicating vein is often located in the scarry tissue beneath the ulcer.

Blood coagulation tests are very significant for therapeutic decision-making in chronic venous insufficiency. Fibrinolytic activity is decreased in patients to varying degrees; the euglobulin clot is lysed within 280-290 minutes (normal is 210-225 minutes), fibrinogen levels are considerably elevated (to 395 mg%), especially in disease exacerbations (to 500-550 mg%). It should be noted that the fibrinogen quantity is increased because of coagulation fraction B in the majority of patients, and because of 'inflammatory' fibrinogen A in some patients. The latter group experiences leukocytosis and an increased ESR.

Today well-elaborate surgical tactics and techniques are available for patients with chronic venous insufficiency: Troyanov-Trendelenburg-Babcock operation, Linton's and Cockett's operations, etc. However, conservative methods, primarily natural healing factors, must also be extensively employed.

Fundamentals of Combined Therapy for Chronic Venous Insufficiency of the Lower Extremities

Natural healing factors (mineral baths, mud therapy, sea bathing, climatotherapy), physical therapeutic procedures, dosaged motor activity play an important role in the combined therapy of patients with different stages and clinical forms of chronic venous insufficiency. However, the therapeutic effect is determined by properly defining the indications for using them and by choosing the appropriate therapeutic methods.

Clinical experience and results of studies show that radon, sulphide, and sodium chloride baths, and mud therapy, sea bathing and climatotherapy improve the general condition of and local and systemic haemodynamics in patients with chronic venous insufficiency (due to varication). These beneficial effects are determined by the fact that all natural factors (especially sulphide and radon baths), exerting specific effect, also contribute to better adaptive trophic functioning of the sympathetic nervous system by improving trophism in vessels, including that in the vascular venous wall. These factors increase vascular tone and reactivity, normalize the function of immune and sympatho-adrenal systems, inhibit the destruction of connective tissue elements and impede the progression of venous varication. The improvement of local circulation and the elimination of vascular spasticity facilitate a reduction of venous congestion and promote the supply of energetic and formative substances, hormones, trace elements and oxygen to tissues, as well as the elimination of metabolites from the body. The pain syndrome is alleviated in patients, the unpleasant sensation in the calves, and heaviness and oedema of distal extremities disappear, and locomotor function improves.

The healing effect depends on the stage and clinical form of chronic venous insufficiency. Therapeutic methods must be chosen on the basis of clinical symptomatology, the degree of circulatory impairment, and the nature of trophic disorders of the skin, subcutaneous fat, muscles, and the specific effect of a balneotherapeutic factor. During compensated and subcompensated stages of the disease, waters of medium concentrations are used for mineral baths (sulphide waters with a concentration of hydrogen sulphide of about 100 mg/l, radon waters—20-40 nanocurie/l, sodium chloride waters with a sodium chloride concentration about 20 g/l), at 36-37 °C, for 15 minutes, for two consecutive days, followed by a day off. During the decompensated stage, especially in the presence of trophic ulcers, the bath regimen is mitigated (low concentrations of hydrogen sulphide—50-75 mg/l, radon—10-20 nanocurie/l, sodium chloride—10 g/l), at 36 °C, for 10 minutes, every other day; physical activity

must be restricted. As the clinical course improves, the intensity of this treatment is increased. Furthermore, physical training exercises and massage may be prescribed (non-focal, since it acts on a reflex basis). During compensated and subcompensated stages of chronic venous insufficiency, the mentioned natural healing factors, especially mud therapy, improve, apart from peripheral haemodynamics, the function of the valvular system, particularly that in communicating veins. This effect is maintained for six to nine months; therefore, repeated courses of treatment with therapeutic physical factors are important as a method of secondary prophylaxis.

Apart from balneo- and mud therapy, combined therapy of decompensated chronic venous insufficiency must comprise physical therapeutic factors, such as decimetre-wave treatment of the lumbar region and long-wave ultraviolet irradiation (non-focal), especially as there are trophic ulcers. Sinusoidal modulated currents may be used concomitantly with ultraviolet irradiation.

Mud therapy is beneficial in the dystrophic form of chronic venous insufficiency. Mud packs at 38-40 °C for 15 minutes, applied every other day for a course of 12 procedures improve trophism, debridement of the wound surface from microflora, damaged cells and purulent discharge, and promote tissue regeneration and even epithelization. Inflammatory alternations around the ulcer resolve, infiltrative abnormalities of soft tissues are significantly reduced, blood circulation is improved, circulatory insufficiency in the distal leg is to a certain degree reversed, and the locomotor function becomes better. The natural healing factors ought to be used even in significant varicosis, indurative, or dystrophic forms of the disease which require surgery. After surgery, natural and transformed healing factors are used for rehabilitation.

Patients with varicosis of any stage or form may be sent for resort treatment, whereas great limitations exist for patients with a history of thrombosis. The time elapsed following sustained acute thrombosis or thrombophlebitis, the status of coagulation and anticoagulation systems, the type and severity of chronic venous insufficiency are of critical importance in decision-making. Resort treatment is indicated in residual phlebitis and thrombophlebitis, not earlier than 3-4 months after acute manifestations subside and not earlier than 6 months following deep phlebitis and thrombophlebitis. These terms are greatly extended for phlebothrombosis. Evaluation of the deep venous system and diagnostic differentiation between sustained deep vein thrombosis and great artery embolism play an important role since therapeutic options depend on them.

Adequate heparinization and early use of desensitizing drugs may lead to abatement of the thrombotic process, canalization of the thrombus, development of the collateral network, and compensation of blood supply in the extremity. However, there is a possi-

bility of thrombotic obstruction of venous vessels resulting in conditions which may lead to venous gangrene, particularly in active form of the disease. Vasospasm in thrombophlebitis may also lead to obstruction of direct venous outflow and severe complications of chronic venous insufficiency. Resort treatment is contraindicated in such cases.

Diagnosis of chronic venous insufficiency of a compensated stage may be delayed in a patient with a history of thrombosis, since local haemodynamic disorders are not marked by the appearing collateral network and scarce symptoms in patients. Therefore, patients with a history of thrombosis having compensated chronic venous insufficiency are sent for resort treatment far less often than patients with subcompensated and, particularly, decompensated disease which is quite prominent clinically. As the patients come to the resort, clinicians must remember that all prescribed natural factors should be applied sparingly to avoid a balneopathologic response and exacerbations. It is the disturbance of coagulation and anticoagulation systems that is dangerous rather than local exacerbation of the inflammation.

It is clear, therefore, that such patients should be sent primarily to sulphide resorts; it is useful to apply short (5-7 minutes) cell sulphide baths of low concentrations (30-50 mg/l) every other day. If no complications occur within five-six days of therapy, sulphide concentrations should be increased to 100 mg/l, procedures should be prolonged to 10 minutes, and semibaths be prescribed. Ten-twelve baths are recommended as an initial course of therapy; these should be combined with therapeutic exercises and non-focally applied massage. The procedures must be delivered by non-intense methods; air and sun baths are also used sparingly*. If patients had received sulphide baths following combined conservative or surgical treatment, they may be sent to resorts with iodine-bromine, nitrogen-radon, sodium chloride and radon waters. At these resorts, the combined therapy must also be applied sparingly: there must be no significant contrasts in water temperature, replacement of some mineral waters with others and no intensive swimming in the swimming-pool, river, etc. As a clinical stability is observed and coagulation and anticoagulation tests are virtually normal, patients may be prescribed a more intensive course of the natural therapeutic factors: intensive hydrokinesitherapy, white or yellow turpentine baths of low concentrations—20 to 25 ml/l (Olefirenko, 1978); greater concentrations can activate the disease.

Mud therapy of patients with chronic venous insufficiency due to thrombosis must be used with greater care than in patients with

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* Tsarfis P. G., Danilov Yu. E. *Guidelines for Patient Treatment at the Resorts of the USSR*. Moscow, 1975, 5-54.

varicosis-associated chronic venous insufficiency of various stages and forms. Initially, mud therapy by mitigated methods is used: mud packs on the affected leg at 38-40 °C, 10-12 minutes, every other day. If there is no balneopathologic response, the mud therapy methods may be intensified after 5-6 procedures. This requires blood testing and evaluation of coagulation and anticoagulation systems indices, thorough clinical examination of the patient, and assessment of the peripheral circulation (using the above tests and methods). If the tests are normal, the patient is additionally prescribed 'mud shorts', raising the mud temperature by 2-4 °C; the procedure is applied for two consecutive days followed by one day off.

Patients as a rule benefit from a therapeutic complex supplemented by hydrokinesitherapy: indurative abnormalities and symptoms of venous insufficiency subside or disappear, skin temperature of the leg is raised, and peripheral blood supply is improved. Leg pain and heaviness disappear and the locomotor function is improved.

In order to enhance the therapeutic efficacy and impede the advance of chronic venous insufficiency, patients should be given repeated courses of resort treatment, and drug and physical therapy should be conducted in the intervals between them when indicated. Only systematic combined therapy can reduce the incidence of relapses and complications in thrombosis-associated chronic venous insufficiency. Therefore, prolonged follow-up and timely modification of employed therapy can act as secondary prophylaxis of the diseases discussed.

Chapter 11. The Effect of Natural and Transformed Physical Factors in Digestive Diseases

Digestive organs have a complicated structure, especially when viewed with not a conventional optic device but the electron microscope. It enables us to see not only an abundance of epithelial and secretory mucosal cells or a mosaic pattern of arteriovenous and lymphatic capillaries, but also the intracellular structure: cytoplasm, nucleus, mitochondria, lysosomes, Golgi's bodies. All these constituents are united with a membrane protecting the cell against environmental intrusions. The membrane surface has receptors interspaced with peculiar 'pores', through which energy and formative materials, oxygen, water and trace elements enter the cell and metabolites are eliminated into intercellular space. What is to be let in or blocked by the cell surface is 'decided' by the receptors: they function as a 'door-keeper'. The receptors are sensitive to biologic and physicochemical processes occurring within the cell and those associated with metabolite accumulation in intercellular space. These processes are automatic. Every organ has specific structures responsible for different functions; the fundus of the stomach contains glands which produce gastric juice and the so-called parietal cells which produce hydrochloric acid; hepatocytes having antitoxic properties and producing bile and glycogen are contained in the liver; the pancreas has Langerhans' iselets which release insulin into the blood. The pancreas produces and releases the juice which is valuable for digestion; it contains various enzymes which decompose fats and facilitate carbohydrate and protein digestion. Since these glands secrete their juices in the duodenum, which play a major role in decomposing and digestion of main nutritional ingredients, I.P. Pavlov termed them the main digestive glands. These glands are supplied with great number of blood and lymph vessels and a huge quantity of neural plexuses whose fibres can receive an infinite number of stimuli and transmit neural impulses to various areas of the central nervous system so that its nuclei and evolutionally produced adaptive neurohumoral systems might participate in the complicated digestive process when required.

The gastric juice and its enzymes as well as juices and enzymes of other main digestive glands break down food to particles which are so tiny that they are able to penetrate into lymph and blood vessels and enter the internal medium of the body via the walls of the stomach, large and small intestine. While gas exchange is mediated by lung vesicles (oxygen enters the internal medium and carbon dioxide is expelled into the environment), the walls of the stomach and intestine admit into the internal medium decomposed proteins, fats, carbohydrates and other food constituents which are purified by the liver cells, rendered harmless, and transferred to all cells and tissues.

These substrates are disintegrated in cells by enzymes, hormones, trace elements and oxygen, and energy is released which maintains a permanent thermal balance, electrical and mechanical processes, ensures constant functioning of the myocardium, smooth muscles of vessels, stomach, intestine, biliary and bronchopulmonary systems, etc. In addition, this energy is required by skeletal muscles for motor activity and working processes both intellectual and physical.

Metabolites which accumulate as a result of the cell activity, its destruction and restoration, get into the blood and are passed to the kidneys, skin, gastrointestinal mucosa and lungs; through complicated conversions and permanently acting neural and humoral mechanisms they are evacuated into the environment.

These very intricate physiological and bioenergetic processes are permanently governed by sophisticated control systems beginning from food ingestion to elimination of 'residues' from the body. Therefore, various digestive diseases can be prevented by clarifying the causes of impairment of these processes and eliminating them. As the disease does occur, it is necessary to find out which regulation links are impaired and what methods can be used to repair or compensate for them. This is achieved by drug and physical therapy, the methods of which are aimed at central regulatory mechanisms, improvement of tissue trophism, abatement of inflammation, and restoration of functioning of the main digestive glands.

11.1 Ulcer of the Stomach and Duodenum

The aetiology and pathogenesis of ulcer have three major determinants: neurosis, disturbance of neurohumoral regulation and that of local mechanisms of peptic digestion. Dysfunctions of the neural system are induced by emotional disturbances, intellectual and psychic strain, viscerovisceral disorders. The very lesion of the stomach or duodenal wall occurs because of a disorder in the neurohumoral mechanisms regulating digestion. This intensifies the digestive action of gastric juice, initially on limited areas of the mucosa and subsequently on deeper layers of the gastrointestinal wall. The

gastric and duodenal mucosa is normally resistant to the digestive action of gastric juice. For self-digestion to occur, a number of factors are required causing either a lower mucosal resistance to digestive effect of the gastric juice or an intensification of the effect. Probably, both factors act simultaneously. Heredity and environmental conditions have been implicated by some investigators in the onset of ulcer, primarily inappropriate regimen and nutrition (irregular meals, prevalence of refined carbohydrates in the diet, excessive intake of poorly or long-digestible food).

A disturbance in the regulatory function of the cortex of greater cerebral hemispheres and subcortical formations leads to an increased tone of diencephalic and hypothalamic areas, which in turn causes overstimulation of the vagus nerve. The increased vagal tone results in hypersecretion of active gastric juice in fasting and other secretory phases, as well as hypoxia due to spasticity of stomach muscles and circulatory disorders in the gastric and duodenal mucosa. Involvement of the hypothalamus causes dysfunctions of other links of the hypothalamo-hypophyseal-adrenal system. The adrenccorticotrophic hormone stimulates the release of glucocorticoids which cause not only gastric hypersecretion and release of hydrochloric acid and enzymes but also a reduction of potassium and sodium levels in the gastric juice, as well as its lower viscosity and mucous content. This indicates the inhibition of the protective function of stomach mucosa. Morphologic mucosal abnormalities in ulcer depend on its localization. With a duodenal ulcer, numbers of major, parietal and mucoid cells are increased. With a stomach ulcer, intestinal metaplasia of the superficial epithelium and disturbance of regeneration processes take place. There are changes in the mucosa of the stomach and duodenum. Pyloric glands show hyperplasia and intensified mucoid secretion of acid mucopolysaccharides which are normally absent. If the ulcer is of long duration, atrophic glandular changes and hyposecretion occur. Apart from secretory disturbances, there is motor-evacuatory dysfunction of the gastrointestinal tract. Ulcer of the stomach disrupts all of its functions: secretory (high acidity and digestive activity during non-digestive period); dyskinesia and reflux (backflow of the duodenal content into the stomach); normal evacuation of food from the stomach into the intestine is impaired. Similar disorders of secretory and motor-evacuatory function accompany a duodenal ulcer.

The ulcer affects functioning of the whole digestive system: cholecystitis, cholangitis, biliary dyskinesia, secretory disorders of the pancreas and liver are commonly found. The simultaneous involvement of vessels and gastrointestinal nerves maintains abnormal impulses coming from the affected site to subcortical and cortical centres, thus closing the 'vicious circle' and causing chronic course of ulcer. A relationship has been discovered between functional distur-

bances of the main digestive glands and that of adaptive systems, hormonal abnormalities and gastric secretory disorders, as well as between functional activity of the sympatho-adrenal system and trophic mucosal abnormalities (as the sympathetic link of this system and the hypophyseal-thyroid system are more affected, the dystrophic changes are greater). Increased activity of the adrenergic system plays a definite role in the pathogenesis of ulcer. It is accepted that this process represents a compensatory mechanism of restoring the inhibited function of the mediator link of the sympatho-adrenal system.

The most obvious X-ray symptom of ulcer is the so-called niche, a wall around the ulcer due to oedema of tissues surrounding the ulcer, and rebuilding of the relief of the gastric mucosa commonly with fold thickening. Concomitant gastritis and functional-morphologic rebuilding of the mucosa largely contribute to the relief alteration. Furthermore, gastroscopy reveals accumulation of mucus around the ulcer, vessel dilation in the mucosa, and induration of ulcer margins related to infiltration and proliferation of cells.

Morphologic studies by Ryss (1966), Gubergrits (1971) and Tolmachev (1971) have demonstrated that half of all ulcer patients have superficial gastritis, much less common is gastritis with gastric glands involvement, and a few patients suffer from gastritis caused by rebuilding.

The type of gastric mucosal inflammation can be determined by endoscopy, as well as its spread and severity, and the condition of the mucosa in different areas of the stomach, especially at the site of the ulcer. Apart from the inflammatory wall around the ulcer, purulent and fibrinoid deposits on its bottom and a pronounced vascular pattern are often evident. These findings are of great diagnostic value since they add to major symptoms and in a certain degree reflect the character and severity of the clinical course. They may indicate a degree of digestive impairment.

The major diagnostic criteria other than pain syndrome and dyspeptic disorders are secretory and motor dysfunction of the stomach and abnormal production of gastric juice (it is excessive in most patients as is free hydrochloric acid concentration).

During the second phase of digestion hyperacid state is revealed in nearly three-fourths of all patients, while a high level of free hydrochloric acid in half of all patients; in addition, elevated pepsin activity is noted in the first phase of secretion. Clinical evaluation of gastric secretion indicates a connection between the acid-producing function of the stomach, the gastromucoproteins content, chlorine, sodium and potassium levels in the gastric contents. A normal or reduced level of sodium and an increased level of potassium commonly accompany hypersecretion of free hydrochloric acid. An increased chlorine level in the gastric contents is associated with in-

creased acid production in the stomach. It indicates that acidity and digestive capacity of the gastric juice are elevated in a considerable number of patients with gastric and duodenal ulcers.

Pain syndrome and dyspeptic disorders are the leading clinical symptoms of ulcer. The pain induces neurosis with multiple vegetative and vascular abnormalities, sleep disorders, irritability, etc. Ulcer pain is associated with the ingestion and kind of food; it has seasonal cycles. The so-called fasting pain is reduced after meals. Abundant, spicy, sour, and salty foods always produce severe pain. Periodicity of pain, its greater severity and duration in spring and autumn are typical and represent a clear diagnostic sign. In most patients ulcer disease is characterized by a cyclic course: spring and autumn exacerbations are followed by remissions (exacerbations are not, however, excluded during other seasons). Seasonal exacerbations are probably closely related to seasonal biorhythms which alter the vegetative functions of the organism and its adaptive potentials. Altered hypophyso-adrenal functions and hormonal regulation may act to trigger exacerbations. Meteorologic components (change of barometric pressure, alterations in solar radiation intensity, temperature, humidity) play a role of stress, thus activating the mentioned trigger mechanisms and exacerbations. The clinician must consider these factors and apply prophylactic measures to prevent a seasonal attack.

Ulcer pain is usually observed along the middle line between the xiphoid process and the umbilicus. With a stomach ulcer, pain is most commonly experienced in the epigastric area above the umbilicus, and with a duodenal ulcer, in the epigastric area to the right of the middle line. Pain irradiation does not depend on the localization of ulcer. These pains may simulate a number of other diseases. Thus, irradiation of pain into the left side, sternum, left scapula may be mistaken for an attack of angina pectoris; irradiation of pain into the lumbar or sacral region may be confused with lumbosacral radiculitis. The pains are caused by spasms and excessive acidity of the gastric juice; they are relieved by cholinolytics.

Vomiting usually occurs at the height of pain resulting in its alleviation. Another very common dyspeptic symptom is heartburn which, like pain, may be seasonally exacerbated. Epigastric tenderness of various localizations may be detected on palpation during acute periods. Tender sites and hyperaesthetic Zaharyin-Head's zones have only limited diagnostic significance.

Furthermore, it should be borne in mind that pain may be associated with reflux-oesophagitis. Abnormal motor function of the stomach causes an increase in intragastric pressure and reflux of the gastric contents (as the cardia constrictor is opened) into the oesophagus. Constant entrance of sour gastric contents into the distal oesophagus induces an inflammatory destructive process in its mucosa.

Erosions occur and the disease becomes chronic and relapsing. Often recurring hiatus hernia further complicates the clinical course. The cardial part of the stomach 'enters' the chest, affecting the physiological mechanism of cardial constriction, and the food is increasingly expelled into the oesophagus. Pain syndrome and dyspepsia worsen.

Sometimes it is difficult to evaluate the character and origin of pain in patients with ulcers and reflux-oesophagitis. It should be remembered that the pain in reflux-oesophagitis is due primarily to spasticity of long oesophageal muscles and often occurs after meals. Pain in reflux-oesophagitis may simulate angina pectoris, but, unlike cardiac pain, it is not related to physical strain and cannot be alleviated with coronary dilative drugs, whereas it can be reduced with alkali drugs. Patient examination (differentiation of the pain syndrome, ECG, appropriate physical loads) and *ex juvantibus* therapy may clarify the origin of disease. The use of pH-metry helps to confirm a lower neutral reaction, usually in the oesophagus. It is associated with reflux of acid gastric contents into the oesophagus, whereby the medium of its distal portion is initially neutralized and subsequently acidified. Endoscopy indicates that the oesophageal mucosa is inflamed due to the inflammatory destructive process; there are oedema, hyperaemia, inflammatory infiltration, occasional erosions, fibrinoid deposits, etc. Clinical and morphologic findings can be discrepant. Reflux-oesophagitis is unresponsive to drug treatment. Therefore, combined resort treatment of patients with ulcer complicated by reflux-oesophagitis plays an important role, since it eliminates the causes of the disease progression.

Sanatorium-resort treatment is indicated for patients with gastric and duodenal ulcers in the stage of remission or subsiding exacerbations, and in the absence of impaired gastric motor function, tendency to bleeding, penetration, and when ulcer malignancy is suspected. It is also indicated for patients in the early stage (one month provided there are no complications) following surgery (stomach resection or vagotomy). The best response is achieved by the therapeutic sequence: hospital/polyclinic, local sanatorium, resort treatment.

Patients require a detailed examination defining the form and phase of disease, secretory, enzymic and motor function of the stomach, the condition of the main digestive glands, associated or concomitant diseases. It is important to determine the patient's reactivity and the nature of local changes in the digestive system.

Combined therapy of ulcer patients consists of drinking mineral waters, mineral baths or mud therapy, under-water enteroclysis and transduodenal lavage, physical therapy, therapeutic exercises, prescribed motor activity, climatic procedures. The treatment is combined with dietary nutrition.

It should be noted that medicopreventive measures for ulcer are based on a complex principle, i.e. a combination of means and methods intended to regulate the patient's life-style with the aim of protecting the nervous system and sparing major digestive functions. Therefore, combined therapeutic measures comprise a sparing regimen and diet, drugs, natural healing and transformed physical factors, prescribed motor activity. The application of these factors must be differentiated, so as to avoid overstrain and ulcer exacerbation, for every acute period is followed by progression of the disease.

When the above-mentioned conservative therapeutic methods fail to alleviate the severity of ulcer and various complications result, surgical methods are used.

Clinical observations show that considerable numbers of patients develop postresection syndromes following various types of gastric operations, precluding their return to occupational activities. However, dumping syndrome, comissural disease and dysfunction of the main digestive glands other than gastric are preventable by timely drinking of mineral waters, application of radon, carbonate-hydrogen sulphide or nitrogen-radon baths, mud or peat therapy combined with dietary nutrition.

Patients' health will improve at any resort where therapy and rehabilitation can be arranged. Moreover, these patients return to occupational activities much earlier than patients who are not treated with natural therapeutic factors. First, it has been demonstrated that gastric, intestinal, hepatic and pancreatic functions are improved in three-fourths of all patients if the recommended factors are prescribed 3-4 weeks after surgery; second, neurohumoral processes are to a certain extent repaired; third, postresection syndromes rarely occur. If such patients are sent for repeated rehabilitation treatment, they return to their work sooner, and functional secretory and motor gastrointestinal disorders practically do not recur.

Periodic examinations of these patients at resorts or after they have returned home show that major functional parameters of adaptive systems (catecholamines, glucocorticoid and thyroid hormones), biologically active substances, protein, carbohydrate and fat metabolism, and coagulation and anticoagulation systems approach average physiological normal values. However, the disease frequently recus because of functional failures of adaptive systems occurring between the courses of therapy and rehabilitation due to impaired physiological defence. Hence, rehabilitation must continue for a few years. Under such conditions, the restoration of the working capacity is more rapid and there are greater numbers of able-bodied patients.

All patients, having undergone surgery or having had an exacerbation of the disease, must be thoroughly examined before they are sent to a spa for conclusive diagnosis of the disease (form and phase)

and evaluation of secretory, enzymic, motor, and evacuatory functions of the stomach (or its remaining portion), the condition of the main digestive glands, and the presence of a neoplasm or concomitant/associated disease.

As appropriate therapeutic-prophylactic measures are planned, it is important to evaluate patient reactivity, i.e. to test responses to any stimuli and compare them with examination results of both the digestive tract and cardiovascular, nervous, respiratory, excretory systems, and systemic or local resistance.

In remission or subsiding exacerbation of gastric and duodenal ulcers, mineral waters are taken orally to regulate gastric secretion, reduce acidity and elevate the enzyme levels required for protein decomposition. Various methods are used for this purpose, depending on ulcer localization, presence of the inflammatory wall around it, prevalence of an hyperacid/anacid state, period of application of these waters (preoperative or postoperative), etc. As motor and excretory gastric functions are impaired (X-ray detected spasms or dilation of the pylorus, delayed or accelerated evacuation of the gastric contents, etc.), warm or cold mineral water, mud or mineral baths and relevant diets are prescribed. The purpose of dietary nutrition is a maximal mechanical, chemical and thermal sparing of gastric and duodenal mucosa. The following dietary guidelines should be observed:

1. Frequent (fractional) meals: 5-6 times a day, in small portions, every 2.5-3 hours, preferably at the same time of the day.

2. Food must contain adequate quantities of protein (120-130 g), half of it must be animal protein (meat, fish, eggs, cheese, cottage cheese, milk).

Quantity of fat is restricted (100 g a day, with allowance for food-contained fats).

Vegetable fats are recommended along with animal ones (sunflower, olive and other oils—20-30 g/day).

Ingestion of carbohydrates, especially easily digestible (sugar, honey, preserves, jam, jelly, mousse, pastry) is restricted, since they may cause heartburn.

3. Meat and fish dishes should only be boiled or steamed, and mainly chopped (cutlets, meat balls, purée, soufflé, meat loaf). Vegetables: boiled, mashed, fine-shredded (in remission period); porridges made of shredded cereals or boiled soft (in remission period).

4. It is recommended to eat food warm; hot and very cold food must be avoided. Food temperatures should not be above 55-60 °C, nor below 15-18 °C.

5. Food and dishes which have strong secretagogue effect and which remain in the stomach long should be excluded from the diet: foods containing extract substances (strong meat, fish and vegetable, especially mushroom, broths, fried meat, and fish, strong coffee, tea),

and hard boiled eggs which are retained in the stomach for 2 hours.

Foods containing a lot of cellulose (cabbage, beans) are also excluded. Marinades, smoked foods, pickles, canned foods, carbonated beverages, alcohol, sweetbreads, pies, black bread, raw ungrated vegetables and fruits, fatty meats and oily fish, ice cream are not permitted.

List of Recommended Foods and Dishes

Beverages. Weak tea, tea with milk or cream, weak cacao with milk or cream.

Breadstuffs. Wheat white bread (one-day old), white rusks, biscuits prepared without shortening.

Dairy products. Whole, dried, condensed milk, fresh unsour cream, fresh unsour shredded cottage cheese.

Fats. Unsalted butter—20 g/day, olive and sunflower oil—20-30 g.

Eggs. Soft boiled eggs, steamed omelette 4-5 times a week.

Soups. Vegetarian, made of shredded cereals (except millet and pearl-barley): oats, rice, farina, vermicelli, vegetable cream soup (except cabbage). Milk soups. Milk or cream may be added to vegetarian soups.

Meat and fish dishes. Lean beef, veal, chicken, turkey, rabbit; non-oily fish: cod, saithe, bass, perch, carp, pike. Made as steamed cutlets, balls, purée, meat loaf; boiled meat and a piece of fish, boeuf-Stroganov made of boiled meat in white gravy—2-3 times a week.

Cereals and macaroni. Recommended porridges: farina, shredded oats (oatmeal), buckwheat, rice (seldom). Millet and pearl-barley are not permitted. Apart from porridges, puddings, boiled vermicelli, baked puddings may be cooked.

Vegetables. Carrots, beets, cauliflower, vegetable marrow, pumpkin, potatoes (restricted); these should be boiled, fine-chopped, as purée, steamed pudding, meat loaf, cutlets. Cabbage is not recommended.

Fruits, berries, sweets. Sweet ripe fruits and berries should be in the form of mashed stewed fruits, jellies, mousse. Raw fruits and berries are not recommended.

Juices. Recommended are raw vegetable (cabbage, potato, carrot) or unsour fruit and berry juices (grapes, apricot, plum, mango, etc.); rosehip water. It is better to have juices after meals.

Foods are moderately salted.

Exemplary Menu

Daily intake: white bread—400 g, table butter—15 g, sunflower oil —20 g, sugar—40 g.

8 a.m. Steamed omelette of 2 eggs, milk—50 g, butter—5 g.

2. Shredded oat porridge. Oats—50 g, milk—100 g (added to water), butter—10 g, sugar—5 g.

3. Tea with milk (50 g milk).

11 a.m. Cottage cheese with milk. Cottage cheese—150 g, milk—200 g.

2 p.m. 1. Vegetable cream soup with skimmed milk. Potatoes—200 g, carrots—100 g, skimmed milk—20 g, milk—100 g, butter—5 g.

2. Meat cutlet, steamed, with mashed beets. Meat—120 g, beets—250 g, bread—20 g, milk—30 g, butter—5 g.

3. Stewed fruit. Dried fruits—30 g, sugar—15 g.

5 p.m. Stale bun or biscuits made without shortening (30-40 g). Tea with milk (50 g milk).

Fish fillet—100 g, potatoes—250 g.

7 p.m. 1. Boiled fish with mashed potatoes.

Fish fillet—100 g, milk—50 g, butter—5 g.

2. Porridge of shredded buckwheat. Buckwheat—50 g, milk—100 g.

9 p.m. Cottage cheese—100 g, milk—200 g.

Gross weights of foods have been given.

Composition: proteins—125 g (60 per cent animal proteins), fats—110 g, carbohydrates—400 g, calories—3200 kcal.

Stomach resection results in new digestive conditions to which the body must adjust. For this reason the patients must adhere to a certain dietary regimen during the first 2-3 postoperative months. Postoperative complications of the stomach stump, intestine and liver are prevented by compliance with the regimen. As has already been mentioned, diet as a major therapeutic and preventive factor is aimed at mechanical, chemical and thermal sparing of the mucosa of the stomach stump, intestine; it also improves hepatic and pancreatic function.

Dietary recommendations:

1. Eating 6-7 times a day, every 2.5-3 hours, preferably at the same time of the day.

2. As heaviness appears in the epigastric area after meals, a meal should be restricted to 300-500 g; solid food is separated from liquid (half a plate of soup followed by 1 glass of stewed fruit, with the second course taken 1-1.5 hours later).

3. It is recommended to eat food warm. Temperatures of food should not be above 55-60 °C, nor below 15-18 °C.

4. Food must contain adequate amounts of protein (120-140 g), with animal protein constituting half of it (meat, fish, eggs, cheese, cottage cheese, milk, kefir).

5. Fats must be restricted to 80-90 g/day, with an allowance for food-contained fats. Permitted daily intake of butter is 20 g, of vegetable oil 30 g.

6. Carbohydrate intake must be restricted to 300-350 g/day, espe-

cially easily digestible carbohydrates: daily allowance of sugar is 20 g, while preserves, honey, jam, chocolate, cakes and other pastry must be excluded from diet.

Permitted daily bread intake is 250-300 g, flour foods and macaroni are permitted only once daily; recommended cereals are buckwheat and oats (oatmeal).

7. Daily diet ought to contain cottage cheese (to 200 g), vegetable oil, cod, oats and buckwheat, vegetables (preferably beets and carrots).

8. Foods must be cooked only boiled and steamed.

9. Foods and dishes containing extract substances (strong meat, fish and vegetable broths, strong tea and coffee, fried meat, fish and vegetables), savouries, smoked foods, pickles must be excluded. Sweetbreads, cakes, pies, cabbage, mushrooms, raw ungrated fruits and vegetables, honey, preserves, alcohol, carbonated drinks are not permitted.

10. Foods producing intestinal gas (cabbage, peas, beans, whole milk, rye bread) must be excluded, and potatoes intake is restricted.

List of Recommended Foods and Products

Beverages. Weak tea with milk, weak natural coffee with milk.

Breadstuffs. One day old wheat bread, biscuits prepared without shortening.

Dairy products. Diluted milk, cream, unsour cottage cheese, kefir, sour milk (all day-old), cheese, except piquant.

Fats. Butter—15-20 g, sunflower, olive and maize oil—20-30 g.

Eggs. Omelette from whites, soft-boiled eggs 2-3 times a week.

Soups. Soups with cereals (except millet) or grated vegetables (except cabbage), vegetarian or weak meat broth (2 times a week); milk soup with vermicelli or rice.

Meats and fish. Lean beef, veal, chicken, turkey, rabbit, non-oily fish (cod, perch, carp, pike, etc.).

Meat and fish made as cutlets and balls should be steamed; boeuf Stroganov from boiled meat; 2-3 times a week when boiled as a piece.

Cereals and macaroni. Any porridge (except millet,) vermicelli, boiled noodles. Buckwheat and oat porridges are preferable. They are made from shredded cereals or boiled soft.

Vegetables. Mashed carrots and beets, cutlets, baked puddings; boiled cauliflower, boiled vegetable marrow and pumpkin with butter, limited amount of mashed potatoes.

Fruits, berries, juices. Sweet fruits and berries (stewed), grated raw fruits, plum, cherry, grape, apple juices, rosehip water.

Exemplary Menu

250-300 g bread a day, 15-20 g table butter a day, 20 g sugar a day.

8 a.m. 1. Two soft-boiled eggs.
2. Buckwheat porridge with milk. Buckwheat—50 g, milk—200 g.
3. Butter—15 g.

11 a.m. 1. Cottage cheese with cream. Cottage cheese—150 g, cream—20 g.
2. Tea with milk (milk—50 g).

2 p.m. 1. Vegetable soup (half a portion) with cream. Potatoes—200 g, carrots—50 g, green peas—30 g, vegetable marrow—250 g, cream—20 g.
2. Steamed meat cutlet with mashed beets. Meat—120 g, roll—20 g, beets—250 g, milk—30 g.
3. Stewed fruit. Dried fruits—25-30 g, without sugar.

5 p.m. Cheese sandwich (cheese—30 g) or lean sausage sandwich (50 g) and tea with milk (milk—50 g) or kefir, or fruit juice (200 g).

8 p.m. 1. Boiled fish with mashed potatoes. Fish fillet—100 g, potatoes—250 g, milk—50 g, butter—10 g.
2. Carrot-and-apple cutlets. Carrots—250 g, manna—20 g, apple—50 g, butter—5 g, one-sixth of an egg, wheat flour—5 g.
3. Tea with milk (milk—50 g).

10 p.m. Kefir—1 glass.

Composition: proteins—130 g (animal proteins—50 per cent), fats—90 g, carbohydrates—350 g, calories—3200 kcal.

If no digestion problems occur after 3 months, the diet may be relaxed during the 6 subsequent months.

Now, foods permitted include brown bread, lean sausages, steeped herrings, cabbage-soup or borshch (2 times a week); fried meat and fish 2-3 times a week, boiled chopped vegetables, raw ungrated fruits, sweet berries, fresh cucumbers (skinned), tomatoes.

Digestion complications require dietary corrections.

Dietary nutrition and oral use of acidic-alkaline or other mineral waters by appropriate methods result in lesser minor injuries to mucosa, lower aggressiveness of hydrochloric acid and lower total acidity, enhanced synthetic and secretory functions of the main digestive glands and recovery of motor, excretory and absorptive functions of the small and large intestine.

These substantial alterations in gastrointestinal functions are determined not so much by local mucosal effects of mineral waters as by significant metabolic and morphologic changes in the main digestive glands. Of course, the direct local influence of mineral waters dissolves mucus, reduces the concentration of hydrochloric acid in

gastric contents, and induces pyloric response. However, their most important effect takes place as micro- and macroelements of these waters enter the internal medium. Trace elements reach the synaptic structures of vegetative ganglia, regulate neural transmission and alleviate vascular spasticity in the stomach wall. They also promote functioning of the noradrenergic link of the sympatho-adrenal system and thereby intensify trophic processes, especially at the ulcerated site. It should be kept in mind that these processes are intensified by low-mineralized waters, whereas interneural sensitivity is suppressed and metabolic processes in mucosal cells are slightly affected by high-mineralized waters with a great content of trace elements. Consequently, the ulcer niche persists and is observed by X-rays at the end of therapy in such cases.

The clinician must also remember that a serious disorder of motor gastric functions precludes oral use of acidic-alkaline mineral waters, since they can enhance secretagogue response and amplify the already excessive gastric secretion. Dosage of mineral water is reduced in inflammatory oedema of pyloric mucosa or spastic pylorus. Guidelines for prescribing oral mineral waters for inhibited gastric secretion are the same as for hypoacid gastritis.

There are other clinical variants of ulcer, requiring individual prescription of mineral water for oral use. If, for example, the ulcer is located in the stomach just below the opening of the oesophagus on the right/left of it or in the stomach orifice, it is advisable to drink mineral waters 20-30 minutes before meals in order to reduce its inhibitory effect: intensity of gastric secretion must not be depressed in such cases. Weakly-mineralized water should also be applied half an hour before meals in patients with gastric and duodenal ulcers in the remission phase.

If, however, the ulcer is torpid and there is a perifocal inflammatory wall, ultra-high frequency electromagnetic waves in decimetre range should be used in therapy. These waves must be applied to the frontal medial surface of the neck where the thyroid is located, not to the gastric areas. Experimental studies of Frenkel and Korolev (1980) have shown that 12-14 procedures with decimetre waves increase thyroid function and the ulcer of the gastric mucosa heals. Similar investigations have been conducted in the department headed by us (Vygodner, 1977). First, it was found that the number of thyroid cells was increased by decimetre electromagnetic waves; second, thyrotropic hormone, tri-iodothyronine, and thyroxine levels increased in the blood; third, endoscopic and X-ray examinations showed a reduction of the mucosal lesion.

It is possible that, apart from neurohumoral effect, decimetre waves directly influence medial cervical sympathetic ganglia and vagal nerves involved in stimulation of trophism of gastric mucous and submucous layers. In addition, this treatment virtually returns to

normal secretory, motor and excretory gastric functions, which cannot be improved by thyrogenic hormones alone.

Clinical observations of many years have shown that this physiotherapeutic factor contributes to healing ulcers of the stomach and improves its major functions much faster than any drug (atropine, vicalin, Almagel, ganglioblockers, oxyferriscorbon, etc.).

Studies on ulcer patients show that their clinical response to drugs is transient, and oxyferriscorbon, although inducing ulcer healing, produces a rough scar which often causes stenosis, especially pyloric. In contrast, no such response is caused by decimetre waves.

If decimetre wave therapy of the thyroid area is contraindicated for patients with gastric and duodenal ulcer, it may be applied to the back of the neck or epigastric area. However, in such cases, the therapeutic effect is seen only in every second patient.

Use of sinusoidal modulated currents is helpful in patients with reflux-oesophagitis. This disease impairs the constrictor-valvular function of the stomach cardia. It has been demonstrated by Kislina (1983), the research assistant of clinical department, that a greater therapeutic effect is obtained by placing the electrodes on reflex areas of the oesophagus and stomach at the level of the seventh cervical-eighth thoracic vertebrae (paravertebrally) than by application of the electrodes on the epigastrium, i.e. in cardial projection.

Clinical studies have demonstrated that paravertebral application of sinusoidal modulated alternating currents at 100 Hz and 50 per cent depth (for 10 minutes) produced a marked improvement of major symptoms. First, endoscopy showed that inflammation was significantly less; second, the constrictor function of the cardia improved; third, intraesophageal pH-metry showed no regurgitation of the gastric contents into the oesophagus.

Surprisingly, acidic-alkaline mineral waters have been recommended for the first time for these patients by surgeons (Petrovsky, Kanshina and Nikolaeva). In due course, not only drinking therapy but also radon baths, mud and peat therapy, and paraffin packs began to be used. Experience shows that the best efficacy is obtained by the combined oral use of mineral waters (as in hyperacid gastritis) and radon baths or by drinking therapy combined with 38 °C mud packs or 46 °C paraffin packs delivered for 15 minutes for a course of 12-14 procedures.

Many years of research have shown that balneo/fango therapeutic factors must not be applied by intensive methods, since sensitivity of the sympathetic and parasympathetic nervous systems is increased and exacerbations are often induced by overdosage.

Pain, regurgitation, severe heartburn, dysphagia and even vomiting are alleviated or even terminated by such an approach. Endoscopy shows marked improvement of catarrhal or even purulent fib-

rinous inflammation of the mucosa, and epithelization of its lesion; a correlation is established between these changes and major gastric functions.

A comparison of results obtained by the three mentioned methods of combined therapy of patients with reflux-oesophagitis indicates that drinking therapy, mud packs and concomitant diet rank first in efficacy, drinking therapy, radon baths and diet rank second, and drinking therapy, paraffin packs and diet, third.

The purpose of diet is to spare the oesophageal and gastric mucosa from mechanical, chemical and thermal effects.

Dietary guidelines:

1. Eating 5-6 times a day, every 2.5-3 hours, in small portions.

2. Food must be warm: food temperatures must not exceed 55-60 °C, nor be below 15-18 °C.

3. Dietary protein must be of an adequate amount (120-130 g), half of it animal (meat, fish, eggs, cottage cheese, milk, cheese). Fat intake is not limited (100 g/day, allowing for food-contained fats). Vegetable oils are highly advisable apart from animal fats (sunflower, olive, maize oils, etc., 20-30 g/day).

Carbohydrate intake should be significantly restricted, especially easily digestible carbohydrates (sugar, honey, preserves, jam, sweets, flour foods), since they may cause heartburn.

4. Food must not contain extract substances irritating oesophageal and gastric mucosa. Therefore, meats, fish, vegetables should be only boiled or steamed. Strong meat, fish, vegetable and mushroom broths, fried meat, fish, and fried vegetables, strong tea and coffee, pickles, marinades, smoked foods, savouries, canned foods, sweetbreads, pies, black bread, pastry, ice cream, carbonated and alcoholic beverages must be avoided.

5. Foods producing intestinal gas must be removed from the diet or drastically restricted: cabbage, potatoes, haricot bean, beans, peas (except green), rye bread.

A list of permissible foods and dishes is given below.

Breadstuffs. Wheat bread (one-day old white), white rusks, biscuits made without shortening.

Beverages. Weak tea, tea with milk, weak natural coffee with milk or cream.

Snacks. Cheese, except piquant, lean ham, lean sausages, milky frankfurters.

Dairy products. Whole milk, fresh sour cream, unsour cottage cheese.

Fats. Unsalted butter, sunflower and olive oil.

Eggs. Soft-oiled eggs, 1-2 times a week, steamed omelette from whites.

Soups. Vegetarian soups made from non-shredded cereals (except millet) and fine-chopped vegetables (except cabbage), milk soup

with vermicelli. Milk or sour cream is added to vegetarian soups. Soup with diluted meat broth, 2-3 times a week.

Meat and fish. Lean beef, veal, chicken, turkey, rabbit made as steamed cutlets, balls, meat purée, boeuf Stroganov made from boiled meat, a piece of boiled meat.

Non-oily fish: cod, saithe, pike, bass, perch, carp (all boiled).

Cereals and macaroni. Shredded porridges or well-boiled porridges, boiled vermicelli. Cereals: all, except millet and pearl-barley. Buckwheat and oat porridges preferable. Manna and rice porridges are not recommended (restrict).

Vegetables. Carrots, beets, cauliflower, vegetable marrow, pumpkin: boiled, fine-chopped, made as purée or pudding. Cabbages, radishes, horseradish and spring onions are excluded, potatoes are restricted. Tomatoes, fresh cucumbers (skinned).

Fruits, berries, juices. Sour varieties of berries and fruits (cranberries, lemon, etc.) are excluded as well as coarse-skin berries (gooseberry, all varieties of currant). Very sweet fruits are avoided or drastically restricted: grapes, bananas, persimmon, figs, watermelon, melon, etc.

Strawberries, peaches, apricots, sweet apples, peeled plums are permitted in small amounts. Juices: mostly vegetable, non-spicy. Fruit juices: unsour and unsweet (plum).

Exemplary Menu

Daily intake. White bread—400 g, butter—15 g, sunflower oil—30 g, sugar—20 g.

8 a.m. 1. Two soft-boiled eggs.
2. Buckwheat porridge. Buckwheat—50 g, milk—100 g.
3. Tea with milk (milk—50 g).

11 a.m. Cottage cheese (150 g) with milk (200 g).

2 p.m. 1. Vegetable soup with sour cream. Potatoes—200 g, carrots—100 g, green peas—40 g, milk—100 g, cream—15 g.
2. Boiled meat with stewed beets. Meat—150 g, beets—250 g (milk—30 g, butter—5 g).
3. Compote from dried fruits without sugar (fruits—30 g).

5 p.m. Biscuits made without shortening—30 g, tea with milk.

7 p.m. 1. Boiled fish with boiled potatoes. Fish—150 g, potatoes—250 g, sour cream—50 g.
2. Carrot-and-apple cutlets. Carrots—250 g, manna—20 g, apples—50 g, one-sixth of an egg, wheat flour—5 g.
3. Tea with milk (50 g).

10 p.m. Kefir (200 g).

Composition. Protein—120 g (60 per cent animal), fats—100 g, carbohydrates—400 g, calories—3200 kcal.

Gross weights of foods have been given.

If patients with reflux-oesophagitis and gastric and duodenal ulcer come to resorts where only radon baths are available, they benefit more from a radon concentration of 80 nanocurie/l than 40 nanocurie/l. Both concentrations are well tolerated by patients. However, the total acid secretion is more greatly reduced by the second concentration.

It has been demonstrated by Gokhar (1983), the research assistant of clinical department, that increased gastric biopotentials of such patients are reduced and the rhythms and forms of electrogastrographic waves are normalized by radon baths. Ulcer healing was noted in 42 per cent of all patients. Also, acidity is reduced, and a spasmolytic effect is produced by radon baths, similar to that of 0.1 per cent atropine sulphate. Probably, thermal and alpha-radiation effects of radon baths eliminate local ischaemia in the gastric and duodenal wall by removing vascular spasms, which, in turn, improves metabolism of mucosal cells of both the cardia and the stomach. Intragastric pressure is also reduced, which favourably influences the pain syndrome, dyspeptic disorders, and functions of the stomach, liver, and pancreas. If radon waters of a sodium chloride base are available at a resort, their application makes the efficacy of therapy 25 per cent higher, especially that of ulcer healing. Such baths reduce excessive serotonin levels, improve protein and carbohydrate metabolism, abate primary symptoms of hyperacid status, improve evacuatory and motor functions of the main digestive glands.

Stable functional recovery of adaptive systems, ulcer healing and elimination of inflammatory infiltration around ulcer can undoubtedly be obtained by systematic treatment and rehabilitation of patients with gastric and duodenal ulcers or those having been operated on for it, and in patients with reflux-oesophagitis. However, complete recovery is not always possible.

11.2 Gastritis: Combined Therapy

Many individuals suffer from inflammation of the mucous and submucous membranes of the stomach, or gastritis. It is a most common stomach disease which often causes digestive tract abnormalities. Therefore, there is every reason to assert that abnormalities of one of the main digestive glands induce functional and, subsequently, organic disorders in the whole digestive system.

It is important to stress that the disease is latent in persons with a long history of gastritis which is histologically proven but is not clinically manifest; hence, patients rarely seek medical care. However, special studies show that every second working patient has the disease.

Causes of gastritis are variable: in some individuals it is induced by exogenous influences, in others by endogenous disorders, and, final-

ly, by genetic susceptibility to stomach disease. The inflammatory process in the gastric mucosa is triggered even by slight dietary faults.

Primary exogenous causes are bad food, intoxicants, especially alcohol and nicotine, chemical production, thermal and chemical agents, and irregular nutrition affecting epithelial and secretory cells, connective tissue, muscular and vascular elements of the stomach. Endogenous causes are genetic liability, impaired regulation of the vegetative nervous system, especially its sympathetic link, and dyshormonism which is induced by various stresses and which can cause both gastritis and gastric or duodenal ulcer.

It has been revealed that the intensity of hydrochloric acid and pepsin secretion may indicate morphologic and functional disturbances of the gastric mucosa. Therefore, the type of impairment can be determined by using potent secretory stimulants. However, in numerous cases free hydrochloric acid fails to be secreted under the influence of histamine. The absence of hydrochloric acid after subcutaneous histamine injection indicates atrophic gastritis which is not responsive to drug therapy. Patients' complaints of poor appetite, sensation of heaviness or swelling in the epigastric area, eructation, and aching or dull pain in the stomach suggest subcompensated gastritis. Dyspeptic disorders and concomitant fatigue, symptoms of biliary, intestinal and pancreatic disease, loss of weight and anaemia are symptoms of decompensated form of the disease.

These abnormalities of the stomach mucosa are related to lower activity of secretory glands and cellular constituents of the gastric wall, as well as involvement of the adaptive systems. Stomach disease involves both the final and other parts of the gastrointestinal tract, liver, pancreas, small intestinal glands, etc. Thus, apart from primary stomach complaints, there are complaints associated with initial abnormalities of the liver and biliary system (bitter taste in the mouth, pain between crura of the right sternocleidomastoid muscle), pancreas (girdle pain in the lower chest), etc. These patients show abnormal chemistries of juices of the main digestive glands, affecting digestive processes, supply of energetic and formative materials, etc. Therefore, regular and adequate meals, rational regimen of nutrition and use of drinking therapy or other natural factors have an important medicoprophylactic significance. The progress of disease can be arrested by avoidance of spicy foods, elimination of unhealthy habits and by adequate nutrition, especially when the disease is still in a compensated phase. Normal life-style and nutrition, avoidance of alcohol and tobacco result in reflex stability of normal activity of secretory glands, i.e. appearance of the so-called priming gastric juice in response to ingested food or, rather, psychological anticipation of food ingestion, and regular release of the gastric juice for digesting food, especially protein. Appropriate

methods of treatment by mineral waters ensure subsidence of inflammation and recovery of secretory, motor and excretory functions of the stomach; functions of other main digestive glands are also improved.

The mechanism of action of mineral waters is very complicated and not yet elucidated in detail, but what is known already is undoubtedly of interest to the reader.

Drinking mineral waters influences the body in various ways, ranging from oral cavity to the lower parts of the large intestine. Moreover, the effect is specific in every part, since the main digestive glands perform various functions of their own and are involved in the complicated process of digestion.

In the mouth, mineral water increases by reflex salivation and salivary concentrations of enzymes, primarily ptyalin participating in glucose disintegration. As mineral water enters the stomach from the oesophagus, its macro- and microelements and alkali decrease acidity of gastric secretions, especially in hyperacid gastritis.

Carbonate, sodium-hydrocarbonate and hydrocarbonate-sulphate-chloride-calcium-sodium-magnesium waters are classic mineral waters which have beneficial effect on proliferation and activation of gastric mucosal cells, regulation, and recovery of secretory, motor and excretory functions of the stomach and intestine. Furthermore, warm and cold narzan and radon waters may be successfully used, ingested right at the spring. These waters are taken orally if their physicochemical properties are preserved and sanitary-hygienic criteria for their oral use are fulfilled (see above). This applies to bottled waters, too. However, experience and special studies show that small physicochemical alterations occur after certain periods; therefore, tests are required every six months to decide on the therapeutic applicability of the waters.

Drinking mineral waters are prescribed on the basis of secretory functions and the form of gastritis. In decreased stomach secretion, mineral water is prescribed as a secretory stimulant 30 minutes before meals, and, vice versa, in hyperacid conditions requiring inhibition of secretion and acidity, the water is taken 1-1.5 hours before meals. However, some mineral waters ingested 1-1.5 hours before meals fail to produce inhibitory effect, which is determined by their physicochemical properties, primarily the content of mineral and trace elements. If water mineralization and concentration of trace elements are low, inhibition of gastric secretion is delayed because sympathetic ganglia are inadequately blocked by absorbed trace elements. Pyloric response to mineral water after its passage to the duodenum is poor and unable to depress gastric secretion. For this reason, therapy ought to include cholinolytics combined with antacids—drugs stimulating regenerative processes: methyluracil, pentoxyl, etc.

Ingested mineral water leaves the stomach and duodenum in as

early as one hour; a significant portion of it is actively absorbed in the small intestine, increasing urinary output, specific gravity of urine and its chloride content.

Undoubtedly, the composition of minerals, ions and trace elements in mineral waters also influences directly muciparous and secretory glands of the gastric mucosa, and indirectly exerts a reflex effect on other main digestive glands, and neurohumoral effect on the adaptive systems. Stimulation of the hypophyso-adrenal and noradrenergic link of the sympatho-adrenal system results in intensification of permissive effect of steroid hormones, abatement of inflammation, and enhancement of mucous cellular trophism. These neuroreflex and enzymic changes contribute to functional normalization of other digestive glands. In addition, water-salt metabolism is activated by absorption of individual constituents in the internal medium of the body, while trace elements entering the systemic circulation and being incorporated by cellular structures intensify the enzymic activity and metabolism, primarily in the gastric and intestinal mucosa and submucosa.

The improvement of secretory activity of the stomach results in a 2.5-time decrease of sodium and calcium concentrations and 3-time increase of potassium concentrations in gastric juice as compared to those in plasma. Secretory function, acidity and enzymic function of the stomach are increased by mineral waters in anacid or hypoacid gastritis with a relative excretory impairment.

These changes significantly improve the clinical course of gastritis: epigastric pain, eructation, bitter taste in the mouth are reduced or disappear, pain is reduced in cutaneous hyperalgesic areas and on palpation of gallbladder and intestine.

Lipid cholesterol and beta lipoprotein metabolism and carbohydrate tolerance are improved by mineral waters. However, drinking therapy must be combined with a rational dietary regimen. A gradual transition from a very strict regimen to a more relaxed one facilitates adjustment of the digestive tract to the permissive regimen. Furthermore, the appropriate prescription of diet in different phases of gastritis reduces inflammation and spares the secretory system, enhances evacuatory and motor functions, and absorption of nutrients. Therefore, hyperacid gastritis with the pain syndrome requires a very strict therapeutic diet (see above).

Diet No. 2 is prescribed in hypoacid or anacid gastritis.

Permitted beverages are tea with milk, cacao and coffee made in water or milk and cream.

Breadstuffs: two day-old white and brown wheat bread, rolls, biscuits.

Snacks: non-piquant cheese, cheese butter, steeped herrings (chopped and herring butter), pressed caviar, soft caviar, lean sausage, milk frankfurters, liver pâté.

Dairy products: milk in tea, other beverages and dishes; dried and condensed milk in beverages and dishes; cottage cheese, cream cheese, sour milk, kefir, acidophilic milk.

Fats: (melted) butter, olive oil.

Eggs: Soft-boiled eggs, omelette (lightly fried).

Soups: different soups made with mild meat, fish, mushroom and vegetable broths with fine-chopped/grated vegetables and shredded cereals (cream soups), borshch, beetroot soup, soup from fresh, fine-shredded cabbage and fine-chopped vegetables.

Meat and fish: different dishes cooked as cutlets from lean beef, veal, pork, mutton, fowl; chopped fish (to avoid a rough crust these foods are not bread-crumbed before frying). Non-oily fish and chicken (boiled).

Cereals and macaroni: shredded and semiviscous porridges, baked puddings, cereal cutlets baked without making a brown rough crust, shredded boiled macaroni, boiled vermicelli.

Vegetables and greens: purées from different vegetables, puddings, vegetable cutlets baked/fried without making rough crusts (without flouring or bread-crumbing), boiled cauliflower with butter, early vegetable marrow and pumkin (stewed), tomato salads; young fine-chopped raw greens may be added to different dishes.

Fruits, berries, desserts, and sugary foods: ripe fruits and berries made as strained compotes, creams, gelatins, jellies, mousses; sugar, honey, sweets, preserves.

Sauces and spices: meta-chopped, sour cream sauces, butter, pepper, very small amounts of bay leaf, cinnamon, small amounts of onion.

Juice: fruit, berry and raw vegetable juices, rosehip and wheat bran waters.

Foods are salted as usual. It is recommended to take 4 meals a day.

Avoid: rich pastries and muffins, bread-crumbed fried meat and fish, fatty meats and fish, pickles, smoked foods, marinades, canned foods (meat, fish, etc.), cold drinks, ice cream.

Exemplary Menu

8-9 a.m. Fried fish cutlets with mashed potatoes, butter sauce. Macaroni with sour cream. Butter. Tea and brown bread.

1-2 p.m. Green pea creamed soup in meat broth, with sippets. Meat balls in tomato sauce with vermicelli. Fruit mousse. Brown bread.

7-8 p.m. Manna pudding baked with grated cottage cheese and sour cream. Carrot cutlets fried without flour or bread crumbs, sour cream sauce. Butter, tea, brown bread.

10 p.m. Jelly, bun.

As the required therapeutic effect is achieved, patients are prescribed a balanced diet.

A neural determinant of diseases, especially neurotic responses manifest differently in a considerable number of patients, greatly influences the clinical course of gastritis. Irritability, temper outbreaks, sleep disorders are exhibited by some patients, and, vice versa, inadequate responsiveness, lack of emotion and inertness are seen in other patients. Skillful combinations of external and oral use of mineral waters, utilization of mud packs or transformed physical factors, particularly in gastritis with pain, have an important medicoprophylactic significance. Neurotic responses are diminished and gastric and intestinal secretory, motor and excretory functions are improved by these procedures. Absorptive and digestive capacities of the stomach are improved, passage of food in the gastrointestinal tract is accelerated, hepatic and pancreatic secretion are increased, and the quantity of energy and formative materials ready to enter the internal medium is increased.

All these processes are extremely important for cellular metabolism, normal functioning of the main digestive glands, and easy functioning of kidneys and other excretory organs.

Through lymph and blood flow, nutrients come to the humoral medium, and neural elements, where they contact reactive sites of these elements involved in motor activity of the digestive organs. Stomach and intestinal passage of food is regulated by mineral waters.

In hypoacid and anacid gastritis, secretory gastric glands are stimulated and acidity and enzyme content of the gastric juice are increased by mineral waters containing organic substances. In addition, the clinical course is favourably influenced by inhibited neurotic responses and regulation of major gastric functions by mineral, particularly radon, baths.

It would be erroneous to view gastritis as local abnormalities of the gastric mucosa alone, since the autonomous activity of the stomach is determined by neuroreflex, neurohumoral, hormonal and other mechanisms responsible for morphologic, secretory, and motor abnormalities which all determine the clinical course of gastritis. Therefore, therapy of patients with gastritis must be comprehensive, consisting of both local and general treatment.

The use of physical therapeutic factors able to stimulate individual functions of the adaptive systems is of great importance. Gastritis with hyposecretion requires the application of decimetre waves using a small-power (25-35 W) Volna-2 apparatus for 8-10 procedures of short duration (10-15 minutes). The combination of these procedures with mineral water ingestion and mud packs accompanied by a therapeutic diet affords significant changes in secretory gastric function. This combination causes the appearance of free hydrochloric acid, intensification of reparation processes and enhancement of function of mucosal glands in patients with secretory insufficiency and

zero acidity. Naturally, these alterations lead to the disappearance of pain, dyspeptic symptoms and epigastric heaviness, and the improvement of digestive function. There is also an improvement in the digestive capacity of the gastric juice and total secretion, enzymic pancreatic function, and bile-secreting function of the liver.

These alterations are more marked in combined therapy comprising 25 W decimetre waves as compared to therapy using 35 W decimetre waves.

Gastritis with secretory insufficiency in a subcompensated stage requires application of ultra-high frequency waves, disk inductor high-frequency electromagnetic waves at 160-180 mA, diadynamic currents, sinusoidal modulated alternating currents, at 100 Hz and modulation range of 25 to 100 per cent, for 3 minutes. In addition, galvanic or sinusoidal modulated currents may be used in novocaine, ganglioblocker, mud or mineral therapy. Drug dosage is 3-4 times lower than in oral or injection therapy. These procedures are alternated with radon baths (40-60 nanocurie/l), or sodium chloride or nitrogen-radon waters. Therapy must also include therapeutic exercises, prescribed motor activity, and paravertebral massage of the Head's zone. This massage is particularly indicated for patients with hyperacid gastritis and ulcer-like pain irradiated to the back.

The liver, pancreas, small or large intestine are sooner or later affected in patients with hyper- or anacid gastritis. Therefore, the diagnosis of these maladies is of great clinical and therapeutic significance.

Chapter 12. Combined Therapy of Patients with Hepatic and Biliary Diseases

There are increasingly greater numbers of patients with hepatic and biliary diseases. This is explained by the inadequacy of available drug therapies used in combination with diet. The disease tends to recur; an exacerbation makes it acute, and conservative methods ensure no therapeutic success. For this reason, about 30 per cent of all patients with cholecystitis require surgery, most commonly cholecystectomy. Moreover, disease is not arrested by removal of the gallbladder; there appear abnormalities of the main digestive glands, hepatic dysfunction, gallstones, fat maldigestion, weight gain, etc.

It is well known that the liver and its biliferous system play a great role in the vital activity of the body. First, the liver represents a central 'laboratory' where all energy and formative materials entering the internal medium of the body are detoxified and processed. Second, the liver produces a composite and efficient secretion (bile) which is involved in decomposition of a most important nutrient ensuring the energy balance—fat. Furthermore, it is involved in the complicated process of thermoregulation and modulation of external appearance. Third, the liver is a reservoir storing a significant quantity of blood; hepatocytes store glycogen which is required for supplying the body with energy.

Thus, energy and formative supply of the body cannot occur without the liver, since decomposed products coming from the environment via the small and large intestine wall cannot join cellular metabolic processes in various organs and systems without prior processing in the liver. Hepatocytes process and detoxify biochemical substrates containing carbon, hydrogen, oxygen, nitrogen, zinc, manganese, copper, iron, bromine, iodine, fluorine, calcium, potassium, sodium, etc. Hepatocytes are also capable of structurally modifying these elements, making them similar to the structure of molecules absorbed by billions of body cells. Because of the specificity of this phenomenon (skeletal muscles require great amounts of some elements while other elements are required by the pancreas, osseous tissue, etc.), supplying cells with energy, building material, water,

trace elements, hormones and other constituents occurs on a differentiated basis. Receptors located on hepatocyte membranes play an important role in this differentiation. According to the cell requirements they 'decide' which elements should be let into the cell and which should be kept out.

Without dwelling on biochemical transformations in the liver and other organs and tissues (this subject requires a special discussion), we will state the great role of the liver in the metabolism and, consequently, in the complicated processes of human life. While a seriously affected stomach or intestine may be partially resected, the liver cannot be removed so far because transplantation is impossible. Therefore, of great importance are measures preventing liver disease. The primary measure is absolute avoidance of alcohol. It is alcohol that most commonly causes severe damage to the liver, which is virtually irreparable. Fatty degeneration and death of hepatocytes are induced by alcohol. Prolonged use of various alcoholic drinks results in liver cirrhosis, i.e. outgrowth of the connective tissue and destruction of hepatocytels. Unfortunately, this process is actually irreversible.

Hepatic function is affected by infections, commonly viral (primarily the virus of Botkin's disease), brucellosis, and numerous chronic infections (cocci, specific tuberculosis, syphilis, helminthic invasion, etc.)

Liver disease is caused by bad food which, apart from intoxication and partial destruction of liver cells, can induce inflammation in the biliary system, ducts and gallbladder. Psychoemotional influences which lead to neurosis play a role in the development of functional disorders of the biliary system. In turn, neurosis causes an impairment in the mobility of the biliary tract, gallbladder, and its ducts. The tone of the biliary system is diminished, bile excretion is slowered and bile congestion develops under such conditions. In some cases, there is activation of an intestinal infection invading the gallbladder, especially *Escherichia coli*, whereby inflammation is induced both in the gallbladder and in the whole biliary tract. In other cases, neural and infectious determinants and, feasibly, genetic traits are the basis of salt deposition leading to stone formation and, together with other factors, the basis of cholelithiasis.

These are causal, or aetiologic, determinants of various hepatic and biliary diseases.

Major complaints making the patient seek medical care for liver and biliary problems are pain in the right hypochondrium, bitter taste in the mouth, lack of appetite, vomiting, irritability, sleep disorders, general weakness. Apart from dyspeptic symptoms and local pain in the hepatic and gallbladder areas, there is repercussion pain, confirmed by positive Kehr, Ortner, Mussy and Zaharov tests. In three-fourths of all patients, the pain is associated with alterations

in physicochemical properties of the bile: increase in its relative density, accumulation of mucus, leukocytes and calcium bilirubin in the gallbladder. Bilirubinaemia, albuminaemia, and decreased detoxifying function of the liver are noted. Alanine aminotransferase, aspartate aminotransferase and quinine oxidase activities are elevated, and cholinesterase activity is depressed.

According to Shkolenko (1971), about four-fifths of patients convalescing from infectious hepatitis show free anti-erythrocyte autoagglutinins in the circulation. One-third of these patients suffer from haemolytic syndrome with persistent indirect hyperbilirubinaemia (in 30 per cent of patients with positive trypsin test of Coombs-Unger and simultaneous decrease in erythrocyte osmotic resistance versus 9 per cent of patients with both tests normal; $P < 0.01$). Half of all patients respond abnormally to intradermal injection of autologous serum.

The levels of acid-soluble fractions (ASF) of nucleic acids are elevated in four-fifths of all patients, exceeding the normal level by 1.5 times. In addition, ribonucleic acid (RNA) levels are elevated in one-third of all patients. Excessive RNA and ribonucleic acid ASF is seen in the presence of enzymic signs of persisting disease or incomplete reparative process in the liver.

What is most characteristic of the convalescent period in infectious hepatitis is inadequate biliary release of trace elements: of copper in two-thirds of all patients, aluminium and manganese in half of all patients, iron and silicon in two-fifths of all patients. At the same time, serum levels of these elements are decreased in three-fifths of all patients, probably due to intensive urinary excretion.

Cholecystography shows a disturbance in bile concentration and absence of marginal shadows and bile stratification in the gallbladder. X-rays show lower contractile ability of the gallbladder and prolonged emptying time. Increased tonus of the gallbladder is observed only in one-fifth of all patients. Apart from these disorders, intrahepatic circulatory disturbances are found in about five-sixths of all patients. This is confirmed by rheohepatographic findings: rheohepatographic waves are transformed into systolic plateaus, there appear presystolic waves and additional waves in the diastolic portion of the curve. Also, the rheographic index and amplitude/frequency values decrease.

Clearly, hepatocholecystitis is responsible for significant abnormalities not only in the hepatobiliary system but also in other functional systems.

Provided that inflammation in the biliary system is induced by infection, especially coccal, and the infection is a determinant of the disease severity, antibiotics must be given a central position in the combined therapy. However, it can be difficult to solve therapeutic and prophylactic problems by drug treatment alone, especially as the

disease becomes chronic and relapsing. Therefore, utilization of natural factors, primarily mineral waters and mud therapy, physical therapy and concurrent dietary nutrition, differentiated physical activities and, when necessary drug therapy, acquire a great medico-biologic and social significance.

Oral use of mineral waters in animals with experimental hepatitis arrests the advance of the disease and results in rapid recovery of major metabolic and antitoxic functions of the liver. Injured hepatocytes are replaced by new ones, and the blood supply of the liver, lipid, carbohydrate, protein, mineral, and pigment metabolism are improved.

Clinical observations of patients with hepatitis (adults and adolescents) treated with mineral waters at resorts during the convalescent period have demonstrated that the early prescription of drinking therapy results in reduced inflammation, enhancement of major hepatic functions and non-specific immune processes, and prevents hepatitis from becoming chronic.

Carbonate chloride-sodium hydrocarbonate or carbonate chloride-hydrocarbonate sulphate sodium-calcium waters combined with radon and carbonic hydrogen-sulphide baths or mud packs to the hepatic area, concurrent diet nutrition and physical activity exert quite favourable therapeutic and reparative effect. The patient feels better: hepatic pain abates or disappears as well as fatigue and dyspepsia, appetite, motor-excretory and secretory functions of the biliary tract and intestine, secretory pancreatic function are improved; patients gain weight, especially young adults.

The clinical response to the mentioned therapeutic complexes is based on the most intricate mechanisms of regulation and reparation of enzymic, hormonal and neurohumoral processes which are affected by the onset and clinical evolution of the disease.

The liver size is reduced, pain in the gallbladder area is abolished, and major indices of lipid, protein and carbohydrate metabolism return to normal as a result of application of drinking mineral waters and mud therapy. Iron-rich mineral water is beneficial for iron deficiency and inadequate iron secretion by the liver.

Both short-term therapeutic-prophylactic and long-term effects are greater in combined use of mineral waters and mud therapy concurrent with therapeutic exercises and diet nutrition. Relapses are less frequent, intervals between hepatitis exacerbations are prolonged, working capacity is increased and rates of disability decreased.

Drinking therapy is beneficial in chronic hepatitis and cholecystitis. Apart from an improvement in the general condition, alleviation of the pain syndrome and dyspeptic disorders, gallbladder pain and the above-mentioned sites of tenderness are abolished, and the liver size is reduced in four-fifths of patients.

Clinical observations have shown that carbonate chloride-hydrocar-

bonate-sulphate-sodium-calcium water and, particularly, sulphate calcium mineral water have greater anti-inflammatory effect on the biliary tract, as compared to carbonated dolomite narzan, chloride-hydrocarbonate sodium, and other mineral waters. Calcium ions may contribute greatly to the inflammation abatement caused by these waters. The discovery of Kostyuk et al. (1983) has shown that the cell neuron has a system of channels which admit calcium ions into the neuron. Ion transfer through the membrane occurs due to specific large protein molecules available in the membrane which function as ion channels. Signals transmitted to the brain from peripheral sites, in particular from neurons of the gastric mucosa and biliary tract, are processed, and a response signal is sent to the target organ. All electric processes occurring in the cell membrane can be monitored and ion channel activities can be controlled with microelectrodes. It has also been documented by the authors of the discovery that ionic currents in the neural cell membrane occur as discrete flashes, every one corresponding to the activation of one protein molecule—ion channel. The numbers of such molecules per unit of cell surface and currents passing through each of them were measured. It was revealed that the flow of calcium ions into the cell via ion channels represents a major link between the processes evolving initially on the surface and subsequently in deep structures of the cell. It was determined which molecular mechanisms enable the superficial membrane to identify calcium ions from the multitude of other extracellular ions and to admit them into the cell. As the calcium ion content of the neuron grows excessive, the flow is arrested until the calcium quantity subsides to the required level.

It is known that orally or intravenously administered calcium solution has an anti-inflammatory effect. As follows from the above concept, mineral water containing calcium ions likewise has beneficial anti-inflammatory effect on the biliary tract and other main digestive glands. The effect is manifested by both clinical and biochemical responses: disappearance of dyspepsia and pain, improved contractility of the gallbladder, and, in subacid gastritis, enhancement of gastric secretory and excretory function.

It has been established by X-rays that there is a certain improvement in the gallbladder ability to excrete congestive bile and it's sphincter functioning. Bile duct drainage is also improved. Bile production and excretion is accelerated by mineral waters. Decreased pretreatment cholate concentrations in bile portion B are significantly increased, lowered and normal concentrations of bile acids in portion C are raised. In addition, the most reliable marker of colloid stability of bile, cholate/cholesterol ratio, returns to normal. It has been emphasized by Galkin et al. (1982-1983) that bacteriologic testing of all bile portions, especially B and C, is required in a modern hospital, since purposeful anti-inflammatory treatment of pa-

tients with chronic cholecystitis is difficult without identification of the microflora and its susceptibility to antibiotics.

In our many years of experience, we have noted that inflammation is significantly diminished by mud packs, mineral water drinking, and mineral baths.

Ingestion of mineral water is helpful in functional abnormalities of liver cells: hyperbilirubinaemia is reduced in four-fifths of all patients, serum albumin levels return to normal and glycoprotein levels are decreased in half of all patients. Furthermore, hepatic glycogen production and pancreatic insular activity are improved.

Some patients have severely impaired ratios of cholesterol to bile acid levels in bile. There appear sites of calcium salt crystallization which collect glycoproteins and metal bilirubinates and which become cores of subsequent stone formation. Examination of gallstones reveals great quantities of cholesterol and trace elements—iron, copper, manganese, nickel, calcium, etc. Cores of the stones have 10-20-fold greater amounts of trace elements than superficial layers.

Stone formation aggravates inflammation in the gallbladder and bile ducts and affects the bile-secreting function of the liver. These processes complicate the clinical course of hepatic and biliary diseases. Besides, gastric secretion is affected and digestive tract diseases are induced in patients with cholecystitis, particularly cholelithiasis.

Combined drug treatment and dietary therapy are aimed at alleviation of the disease. If, however, cholelithiasis attacks are increasingly frequent and inflammation is activated, particularly when there are many stones in the bile ducts, surgery is inevitable. Inflammation is reduced by removal of stones and the gallbladder. Patients are subject to resort treatment, and the natural factors available at resorts play an important prophylactic role: changes in bile secretion, alleviation or termination of stone formation, and intensification of major functions of the liver. Mineral water drinking increases the stability of vesical reflux and improves bile evacuation both from the gallbladder and the biliary tract as a whole. Absorbed by the lymphovenous system, mineral water constituents are incorporated into the hepatocyte metabolism, improving hepatocyte function and activating the digestive process.

It is useful to combine drinking therapy and mineral baths, since the latter intensify these processes on a reflex and neurohumoral basis, and achieve stable therapeutic and rehabilitative effect.

Radon and nitrogen-radon baths have certain advantages over carbonate-hydrogen sulphide and chloride sodium baths, both in terms of reducing neurotic responses and modifying the hepatic and biliary functions.

Radon baths are more efficient in reducing pain, dyspepsia, neurosis and in improving appetite and reducing or eliminating Kehr,

Ortner, Mussy and Zaharov symptoms, compared to oral application of the same mineral water concomitantly with carbonate-hydrogen sulphide baths. Involution of the liver and gallbladder is greater in combined radon therapy than with therapy including carbonate-hydrogen sulphide baths. No adverse response of the liver to low concentrations of hydrogen sulphide (10 to 20 mg/l) is observed.

Blood supply of the liver and periodicity of bile discharge are improved by the two therapeutic complexes in three-fourths of all patients, and latent periods are normalized in four-fifths of all patients. However, clinical alleviation of dyskinesia, reduction of hyperalgesic sites and enzymic test improvement are more marked with application of radon and nitrogen-radon baths as compared with carbonate-hydrogen sulphide baths.

Carbonate-hydrogen sulphide baths restore hepatic pigment and protein function in greater number of patients than radon baths (approximately 2:1). It is important to note that various degrees of disease activity require differentiated use of the mentioned baths. In recently-sustained hepatitis and absence of active disease, the best results are obtained by sparing methods of balneotherapy (bath duration 6-8 minutes, a course of 8-10 baths administered every other day plus diet nutrition). On the contrary, more intense methods are used 8-10 months after jaundice in the absence of signs of active disease, such as positive alanine aminotransferase test (bath duration 15 minutes, baths administered on two consecutive days with an interval of 1 day, i.e.5-6 procedures a week; total 14-16 baths).

Diet nutrition plays an important role in the combined therapy of patients. Its principles are:

1. Frequent (fractional) meals, 4-5 times a day, every 2.5-3 hours, preferably at the same time of the day.

2. Food must contain an adequate quantity of protein (100-120 g), half of it must be animal protein (meat, fish, low-fat cottage cheese, cheese, milk, eggs).

Fats must be restricted to 70-80 g/day (allowing for food-contained fats). Daily butter intake is 15 g. It is recommended to use 20-30 g of vegetable oils (sunflower, olive, etc.) every day, adding them to salads.

3. Apart from vegetable oils, daily diet should contain cottage cheese (about 200 g), cheese, cod, oat or buckwheat.

4. Vegetables, fruits, vegetable and fruit juice ought to be used every day since they are major vitamin sources; cellulose of vegetables and fruits helps to prevent constipation.

Potassium-rich vegetables and fruits are recommended to improve biliary tract function: dried apricot, raisins, fig, prunes, bananas, rosehip, oranges, dates, peaches, cabbage, baked potatoes, turnip, fresh cucumbers.

5. Fluid intake (soups, compotes, etc. included) must be increased to 2 l/day unless there are cardiac problems.

6. Salt intake is slightly reduced: 8 g/day (teaspoonful). During an acute period, food ought to be cooked without salt.

7. All foods (meat, fish, vegetables) are cooked only as boiled, steamed and, occasionally, stewed dishes without fat.

8. High cholesterol foods (brains, liver, kidneys, heart, tongue, yolk, any caviar) and extract substances (strong meat, fish and mushroom broths, fried meat, fish, vegetables, strong tea and coffee) must be excluded from the diet.

Pickles, smoked foods, marinades, savouries, canned foods, fatty meat and fish, biscuits prepared with shortening, cakes, cream, alcohol are not permitted.

List of Recommended Foods and Dishes

Breads. Brown bread (made of wheat and rye). Bran bread, biscuits without shortening.

Soups. Vegetarian cereal, vegetable, beetroot, fruit, milk, cabbage soups, borshch.

Meat and fowl. Non-fatty beef, veal, chicken, turkey, rabbit, cooked by boiling, backing, chopped or as a whole piece (boiled chicken, boiled meat, boeuf Stroganov, cutlets, meatballs, etc.).

Fish. Non-oily fish: cod, pike, navaga, carp, perch. Cook like meat and fowl.

Vegetable dishes and garnishes. Carrots, beetroot, cabbage, cauliflower, green peas, lettuce leaves, tomatoes, potatoes, fresh cucumbers. Eat raw, boiled or baked.

Cereal and macaroni dishes and garnishes. All cereals, preferably buckwheat, oat; macaroni, vermicelli. Beans are excluded. Cook in water, milk, as porridges, puddings, cutlets, dumplings.

Eggs. Baked omelette from whites. One egg 2-3 times a week.

Fruits, berries, desserts, sweets. All fruits and berries raw and boiled, except sour; desserts, sugar, honey and preserves in normal quantities.

Dairy products. Whole milk if no flatulence occurs, kefir, acidophilic milk, sour milk, low-fat cottage cheese, sour cream as a sauce, cheeses.

Snacks. Non-piquant cheese, mixed salad without pickles, steeped herrings 1-2 times a week.

Beverages. Weak tea and coffee. Raw-fruit sweet juices, rosehip water. Carbonated drinks must be avoided.

Fats. Only butter (10-20 g) and vegetable oils (maize, sunflower), 20-30 g/day.

Exemplary Menu

Bread. Wheat bread from lower-grade flour, 300-400 grams a day; table butter, 15 grams a day; sugar—50 grams, sunflower oil—30 grams.

8 a.m. 1. Mixed salad: potatoes—150-200 g, carrots—100 g, beets —100-150 g, onions—10 g, vegetable oil—20 g.
2. Cheese—30 g, butter—15 g.
3. Tea with milk (milk—50 g).

11 a.m. Fruits (1-2 apples or oranges) or fruit juice—200 g.

2 p.m. 1. Vegetarian cabbage-soup: fresh cabbage—200 g, potatoes—150 g, carrots—50 g, onions—10 g, sour cream—20 g.
2. Meat cutlets, steamed, with stewed beets: meat—120 g, bread—20 g, beets—250 g, milk—30 g.
3. Stewed fruit: dried fruit—25-30 g, sugar—15 g.

5 p.m. Fruits or juices, or sour milk products—250 g.

8 p.m. 1. Buckwheat porridge with milk: buckwheat—50 g, milk—250 g.
2. Cottage cheese with sour cream: cottage cheese—150-200 g.
3. Tea.

10 p.m. Kefir.

Meat and vegetables have been represented in gross weights.

Composition: proteins—100 g (animal proteins: 50 per cent), carbohydrates—400 g, fats—90 g, caloric intake—2800 kcal*).

The course of disease is favourably affected by oxygen mixtures, vitamins, sparing or tonic physical activities.

The use of mineral baths and, especially, mud therapy is helpful in improving blood supply of the liver, transport of energy and formative materials, and enhancement of major metabolic functions of hepatocytes. Regenerative capacity of cell constituents, blood filling, glycogen deposition and digestive and excretory functions of hepatocytes are, in turn, improved.

Bile-secreting function of the liver is intensified by mineral waters containing organic substances: first by inhibiting bile secretion and subsequently by increasing the quantity of bile. Biliary bilirubin and cholesterol levels are elevated and blood levels of these substances are reduced after treatment with these waters. It has certain significance for cholesterol level reduction, especially in obesity-prone and hypertensive females.

Observations of patients with intestinal fistula receiving low mineralized waters have demonstrated that three-fourths of the water

* All diets are composed by Ostrovskaya, an experienced dietitian of the Institute of Physiotherapy and Spa Treatment.

are absorbed in the upper parts of the small intestine, and only one-fourth reaches the caecum. It has also been established that waters containing sulphate and magnesium ions are more slowly absorbed through the small intestinal walls than are low mineralized waters. The intestinal contents is increased in such cases not only as a result of water inflow from blood via the intestinal wall, but also of enhanced secretion of intestinal mucosal glands. Secretion of bile and other digestive juices is also intensified.

After intestinal absorption the mineral water and its main macro- and microelements enter the liver via the portal system, and join the metabolic processes of hepatocytes both through reflex and neural pathways. Furthermore, sulphate ions of mineral waters cause intensification of bile production and secretion, bilirubin and cholesterol elimination, emptying of the gallbladder and bile ducts from congestive bile (crystals, epithelium, bile acids), and motor improvement of the whole biliary system.

It should be borne in mind that normalization of physicochemical properties of bile is of great significance in the prevention of stone formation. Therefore, the drinking of mineral waters and application of mineral baths significantly help to prevent cholelithiasis. Greater therapeutic effect is obtained by combining balneologic and dietary therapy.

If there are no clinical symptoms of active infectious hepatitis, it is useful to apply mud therapy 6-8 months after jaundice subsides. Dyspeptic disorders are corrected or terminated by mitigated mud therapy in three-fourths of all patients. Clinical studies have shown that the pre-icteric period of hepatitis simulates the exacerbation of coronary atherosclerosis in some patients: there are retrosternal pain, ECG abnormalities, repercussion pain in the left arm, etc. Aggravation of dyspeptic syndrome, catarrhal symptoms, arthralgia and malaise are simultaneously observed. Application of physiotherapy in these patients is of little efficacy. Observations of many years have led us to conclude that physical factors should be employed in therapy of such patients only after abolishing (by drug therapy) clinical, enzymic and ECG manifestations of active disease and coronary circulatory disorders. Moreover, the acclimatization and adaptation period for patients coming to a resort must be extended to 5-6 days. During this period, the patients are subjected to a detailed examination and additional treatment with vasodilators, lipotropic agents and vitamins simultaneously with restriction of physical activities and oxygen therapy. Non-intense methods of balneologic therapy are used: common 8-10 minute baths every other day, at 36 °C, a course of 10 baths. It is preferable to administer mineral gas baths in an oxygen tent, since apart from optimum utilization of the therapeutic effect of the baths, systemic oxygen saturation, better circulatory transport, reduction of myocardial ischaemia and

stimulation of myocardial metabolism are achieved. Mud therapy is contraindicated for these patients.

Patients with infectious hepatitis can develop Osler-Rendu disease. It often occurs as cutaneous telangiectasia with a bleeding tendency (nasal. uterine, haemorrhoidal, intestinal, etc.). Capillaroscopy shows abnormal capillary structure: capillaries are excessively long, dilated and tortuous; vascular aneurysms, arteriovenous anastomoses and sluggish circulation are often observed. Patients with this syndrome display lower rheographic values, especially in vessels of the upper and lower extremities, which differ from those observed in atherosclerotic occlusions. Patients exhibit ECG symptoms of coronary insufficiency, abnormalities of eye fundus vessels, varicosity of major veins of the lower extremities.

The consequences of infectious hepatitis with Osler-Rendu syndrome warrant a close follow-up for new bleeding symptoms. For this reason, all balneotherapeutic factors must be applied with caution and by mitigated methods. An alternative treatment of these patients includes radon baths, drinking of mineral water, dietary nutrition, morning exercises. Gastric lavage, transduodenal and rectal procedures are contraindicated.

Combined resort therapy influences favourably the clinical course of the disease, indices of hepatitis activity and coagulation and anticoagulation tests (higher plasma heparin tolerance and lower fibrinolytic blood activity) in three-fourths of all patients. Cardiovascular function is improved in one-third of all patients (capillaroscopic findings are normalized and vascular spasticity and vegetovascular dystonia are reduced).

The natural physical factors are successfully used in patients with a history of infectious hepatitis both for therapeutic and rehabilitation purposes. It should be kept in mind that balneo- and fango therapy and motor loads should be intensified as inflammation activity declines. The above-mentioned mitigated therapeutic methods cannot ensure the restoration of working ability of patients and their return to occupational activities. On the other hand, it should be remembered that intense application of rehabilitation treatment of active disease at resorts can induce exacerbation of hepatic and biliary inflammation. Therefore, an accurate evaluation of the patient's condition and the course of hepatitis is helpful in prescribing the optimal therapeutic and rehabilitation complex in various phases of the disease.

Experience with repeated courses of treatment of such patients indicates that adherence to the principle of successive treatment, i.e., sending the patient to the resort immediately after an acute period and repeated rehabilitation treatment after 6-8 months, considerably increases the efficacy of the natural physical factors, as compared to the recent practice of applying them only 1-2 years

following the acute period. With such an approach, the natural therapeutic factors acquire not only medicobiologic but also socioeconomic implications.

Clinical experience shows that all natural factors must be prescribed on a differentiated basis: with regard for the physicochemical nature of the factor, on the one hand, and the course of dystrophic or inflammatory disease, on the other.

In biliary tract inflammation and parasitic invasions, transduodenal lavages (water flushing circumventing the stomach) and biliary tract drainage are used. These procedures help to clear the gallbladder and bile ducts from congestive bile, reduce inflammation, and activate the motor function of the whole biliary tract. These procedures are not used in calculous cholecystitis, since they may provoke acute cholelithiasis.

Under-water enteroclysis and microenemas are used in hepatic and biliary diseases as important constituents of combined therapy, particularly when liver and pancreas diseases are associated with intestinal disorders. Decision of a physician is individual for every patient, since indications and contraindications are presently available for the application of various types of mineral waters, fangoes, and climatotherapeutic procedures. Instituting these procedures too early can exacerbate or complicate the disease. Therefore, knowledge of intestinal dysfunctions and their clinical manifestations are of great practical importance.

Chapter 13. Combined Therapy of Various Diseases of Joints

Therapy of patients with diseases of joints is associated with numerous complicated, debatable, and unresolved issues, because there is no standard concept of these diseases. Their clinical manifestations vary. Classifications of diseases and approaches to therapy vary with countries, and therapeutic effect is short-lived. Naturally, all of this negatively influences the efficacy of treatment. Diseases often become chronic with a progressive and relapsing course. As a result, there are increasingly greater numbers of people incapacitated for work who often become disabled.

Statistical data of the Committee of the American Rheumatism Association indicate that 4.5 per cent of the population in the USA are affected by rheumatism and diseases of joints; the total number of patients with diseases of joints registered in 1976 was 20 million 250 thousand, of which 5 million patients suffered from rheumatoid arthritis, 12 million from osteoarthrosis, 2 million from gouty arthritis; children with arthritis numbered 25 000 and patients with other forms of arthritis 1 million.

According to Robinson (1980), the annual financial loss associated with rheumatic disease in the USA is 13 billion dollars, and 44 million sick leave days have been attributed to these diseases in Great Britain.

It has been reported by Altus, Schedwill and Klinger (1979) that the annual costs of in-patient treatment in the FRG are 1553 million marks and those of out-patient care 1400 million marks. The annual overall damage to the national economy as a consequence of these diseases is 14 million marks.

In the GDR, rheumatic diseases represent the second cause of primary disability of females and the fifth cause in males.

According to Sievers, Klaukka and Takkala (1983), the overall incidence of rheumatic diseases in Finland was 8.8 per cent in 1964 and 43.3 per cent in 1976, i.e., there has been a 69 per cent increase. Spinal disease (3.6 and 7.1 per cent for the respective years) and osteoarthrosis (0.7 and 3.2 per cent) incidence rates account for this

jump. According to the World Health Organization, 23 per cent of all disability pensions in Finland are associated with rheumatic diseases. It should be noted that 61 per cent of these patients also suffer from cardiovascular diseases.

Altus et al. (1979) have presented evidence that of 30 000 follow-up patients with rheumatic diseases 20 per cent were disabled by rheumatoid arthritis (RA) and 21 per cent by ankylosing spondyloarthritis (AS). Similar data for RA have been reported by Korshunov et al. (1979); according to these authors, 4.6 per cent of the patients were disabled within 2 years after the onset of disease. Moreover, it has been reported by Bolotina et al. (1981) that grade I disability due to RA occurred in 30 per cent and grade II disability in 53 per cent of patients below 40 years of age. Rheumatism severely affects the heart, it acquires a relapsing course and is associated with a high rate of cardiac disease. As a result, life expectancy is significantly reduced; according to Dolgor (1976), it is 30.3 years for females and 31.2 years for males. As reported by the same author, the rheumatism-associated mortality rate is 2.67 per cent. It was stated by Dolgor that disability rates have been increasingly growing in recent years. Thus, the proportion of rheumatic diseases in overall disabling causes was 9.6 per cent in 1976, and it rose to 19 per cent in 1980. The high rates of disability in 1980 due to rheumatic diseases are determined not only by year-to-year expansion of numbers of the disabled due to the inadequate treatment but also by growing numbers of the primarily disabled. This was the case with RA which accounted for 21.7 per cent of primary disability in 1980. Other causes aside, low efficacy of therapy and rehabilitation care account for high rates of primary disability which obviously results when drugs alone are used in patients, with no physical therapy.

It has been reported by Bobylev et al. (1983) that over half of the patients (54.8 per cent) had grade II disability; 4.1 per cent were completely incapacitated and required constant care (grade I disability); finally, 41.1 per cent of the patients were partially incapacitated for work (grade III disabilty).

Nasonova et al. (1977) point out that owing to medicoprophylactic measures, the proportion of patients with rheumatism-associated grade II disability is reduced (from 72.3 to 53 per cent) because of an increasing (from 27.7 to 47 per cent) proportion of patients with grade III disability. Data of Aseeva and Kartashov (1977) indicate that an early dispensary care* and institution of effective med-

* Dispensary care envisages the active follow-up of the health of certain groups of the population by physicians of different specialities, study of their working and living conditions, the assurance of their correct physical development and preservation of health by carrying out adequate therapeutic, prophylactic, sanitary, hygienic, and social measures (*Ed.*).

icoprophylactic measures as in-patient or out-patient treatment result in a 2-fold reduction of workday loss and a 1.5-fold reduction of relapse periods in RA and AS patients.

According to Maksimova et al. (1980), the annual cost efficiency of a rehabilitation centre amounts to millions of roubles owing to early diagnosis, treatment and prevention of rheumatic diseases.

Results of epidemiologic studies have demonstrated a high incidence of degenerative articular and spinal diseases.

According to Tichy (1969), 4 per cent of the world's population are affected by various diseases of joints. The incidence of primary arthrosis deformans (AD) in population studied by Eryalis (1973), Scorzelli and Vitale (1970) ranged from 25 to 40 per cent. According to Bryul (1971), arthrosis deformans comprises 15 per cent of all diseases of joints in patients aged 40 to 60 years and occurs almost in 100 per cent of persons over 60.

The rate of AD morbidity in the population varies with geographic areas of the USSR. It has been reported by Devaitene (1968) to be 4.16 per cent in Kaunas. According to Nutrikhina and Korovina (1972), the proportion of AD in overall morbidity is 5.7 per cent in Arkhangelsk. The incidence of AD has been especially high in industrial workers: in a study of Sinilo et al. (1977) it was 18.8 per cent.

Goubis et al. (1977) have found disability rates to be growing in patients with osteoarticular diseases. During 5 years, there has been a 19.8 per cent increase in disability rates, with AD accounting for one-third of all cases.

During recent years the incidence of AD has tended to increase. It has been discovered by Pätiälä et al. (1975) that the rates of working incapacitation due to RA decreased, while numbers of persons incapacitated by AD increased by 3-5 times.

Evidence of Podchalimova (1982) indicates that the incidence of AD is 13.6 per cent in Poland, 5.4 per cent in Italy, and 41.7 per cent in Romania. The proportion of AD in rheumatic diseases has been reported by Bobylev et al. (1983) to be 62.1 per cent, females accounting for 89.4 per cent and males for 10.6 per cent of all cases.

Thus, inflammatory and degenerative joint and spinal diseases are common in the world population; they produce enormous rates of temporary working inability and lead to early disability. Hence, treatment of the patients has both medicobiologic and socio-economic importance.

13.1 Utilization of Natural and Transformed Physical Factors in Therapy and Rehabilitation of Patients with Arthrosis Deformans

Arthrosis deformans (AD) most commonly occurs due to exogenous and endogenous factors causing joint defects.

Psycho-emotional strains, minor injuries, systematic overstrain of one or several joints associated with occupational activity, overstrain of one extremity because of disease of the other, all cause an impairment in the congruence of constituent surfaces of the joint.

The role of mechanical factors is confirmed by the fact that leg joints are more commonly affected, since they are involved not only in locomotion but also in static function. Static disorders are induced by various injuries, subluxations, congenital malformations of bones and joints affecting the alignment of joint surfaces.

Osteoarthrosis deformans often occurs due to intraarticular fractures resulting in secondary degenerative processes both in the joints and in surrounding tissues, and in trophic disorders of other joints. Because of the injury of the neurovascular bundle, the patients develop lymphovenous insufficiency complicating the clinical course of secondary osteoarthrosis deformans.

The above data indicate a doubtless role of injuries in primary and secondary osteoarthrosis deformans. It would be erroneous, however, to attribute all clinical forms to trauma alone. The dystrophic process in the joints is basically associated with abnormal blood supply to the synovial membrane, reduced synovial fluid volume, and impaired cartilage metabolism.

Nakonechny (1967) had demonstrated two phases of alteration in the vascular network of joint tissues: vascularization of the synovial membrane and fibrous joint capsule is increased in the first and decreased in the second phase.

Some clinicians (Mekotina and Spiridonov, 1962; Hackenbroch, 1957) have concluded that the pathogenesis of arthrosis and that of atherosclerosis have much in common, and these different conditions may take similar clinical courses. However, clinical observations suggest that atherosclerosis as a determinant of articular degeneration may be prevalent in elderly individuals.

Thrombosis of intraosseous vessels, especially in the femoral neck, leads to bone necrosis, resulting in coxarthrosis.

The trophic disorders seem to be caused not only by morphologic changes in vessels, but also by metabolic disorders in the vascular wall itself.

A drastic reduction in amino sugar (protein polysaccharide) content in the cartilaginous matrix has been found out by Moskowitz (1973) in knee arthrosis induced in rabbits by meniscectomy.

Tsenov (1965) and Dziadek (1973) observed in certain muscles marked hypotrophy which was due not only to pain-associated contracture and joint rigidity but also to neurotrophic disorders.

According to Veliaminov (1924), Diterikhs (1937), Speransky (1955) and Tsarfis (1973), any neurovascular regulatory disorders can lead to an impairment in nutrition of the joint constituents and metabolic disturbances in joint tissues. Thus, trophic disorders closely associated with neurovascular abnormalities constitute the basis of various degenerative lesions of joints.

Clinical observations suggest a role of endocrine disorders in some degenerative joint diseases. It has been discovered that Heberden's nodes and arthrosis of the knees occur more commonly in females during menopause. In their studies on the role of menopause in primary chronic polyarthritis, Stecher (1961), Kovals and Hutteren (1966) came to the conclusion that menopause is not a direct cause of the disease, although it plays a role in its development and clinical course.

M. Silberberg and R. Silberberg (1941, 1950, 1965) have shown experimentally that growth of the epiphyseal cartilage is inhibited by administration of pituitary adrenocorticotrophic hormone (ACTH). It has been established by Zuchereni and Vignon (1958) that the degenerative process in the cartilage is mitigated by administration of an extract of the anterior hypophysis to animals. The role of thyroid hypofunction in the development of osteoarthrosis deformans has been debated by Astapenko and Pikhlak (1966). However, a pronounced therapeutic effect has been demonstrated by Weisenbach and Francon (1973) by rubbing thyroxine into knee-joint areas in patients with osteoarthrosis deformans.

It should be emphasized that endocrine factors play an important role in AD, although the complexity of the disease cannot always be explained by them. Impairment in cartilaginous metabolism is to a certain extent determined by hormonal factors, but progression and clinical features of the disease are dependent on other numerous intra- and extracellular processes.

Hackenbroch (1958, 1968) put forward a theory of 'prearthrosis' which implicates proneness to degenerative disorders. The author qualifies as 'prearthrosis' congenital malformations and those associated with joint bruises ignored by patients. In the author's opinion, arthrosis arises because of a qualitative impairment of articular cells.

According to Rusakov (1959), alterations in subchondral bone segments interpreted as aseptic necrosis actually result from congenital or acquired skeletal defects.

Overcooling, common chills and humidity have been implicated by Diterikhs (1937), Astapenko and Pikhlak (1966), Tsarfis (1969), and other authors as important determinants of arthrosis, since apart from systemic neuroreflex influence, these factors have local effect

on the joints, cause osteoarticular ischaemia, can lead to thrombosis of capillaries and small lymphatic vessels of the synovial membrane. These changes result in an impairment of osmosis and diffusion, affecting epiphyseal cartilage nutrition.

According to Fletcher (1955) and Stepanek (1962), obesity is associated with constant overload of the joints and resultant degenerative disorders.

The study by Chepoy (1969) of patients with osteoarthrosis revealed a disturbance of mucopolysaccharide metabolism with elevation of chondroitin sulphate A levels. According to Volkhonskaya (1960), degeneration of the epiphyseal cartilage is associated with its dehydration and strong reduction in oxygen intake. Enzyme system dysfunction is considered by Kupchinskas et al. (1967), Ruches and Russland (1966) to be the basis of this disease. Studies of alkaline phosphatase and cholinesterase activity and proteolytic activity of blood and synovial fluid have shown elevated alkaline phosphatase activity in blood and its decreased activity in the synovial fluid of numerous patients (especially elderly) with osteoarthrosis.

The above evidence indicates that various environmental factors, such as trauma, nervous system lesions, vascular abnormalities, and endocrine, metabolic and genetic constitutional factors play a definite role in the development of disease, but they do not disclose the complicated mechanisms underlying arthrosis.

The adaptive-trophic function of the sympathetic nervous system is impaired by a combination of these factors rather than a solitary factor, and abnormalities inducive of degeneration of major joint elements develop gradually. This concept is supported both by clinical, morphological and biochemical studies. Since the impairment of the adaptive-trophic function of the sympathetic nervous system in patients is associated with repeated negative effects, the degenerative joint disorders evolve much more slowly than those associated with inflammatory diseases. It must be stressed that degeneration occurs not only in joint constituents but also in skeletal muscles and visceral organs. Therefore, myocardial dystrophy or impairment of secretory and digestive functions of liver, kidneys or cells of other organs must be viewed as a single pathogenetic process.

Clinical observations and studies of recent years have expanded the understanding of the aetiology and pathogenesis of osteoarthrosis deformans, but the above interpretations of roles of the mentioned factors in degenerative articular diseases have not so far enabled specialists to compose an integrated concept of the complicated occurrences underlying the disease.

Complex X-ray, biochemical and clinicomorphological studies of blood serum, metabolites in 24-hour urine, structures of the synovial membrane and epiphyseal cartilage, conducted in the recent years

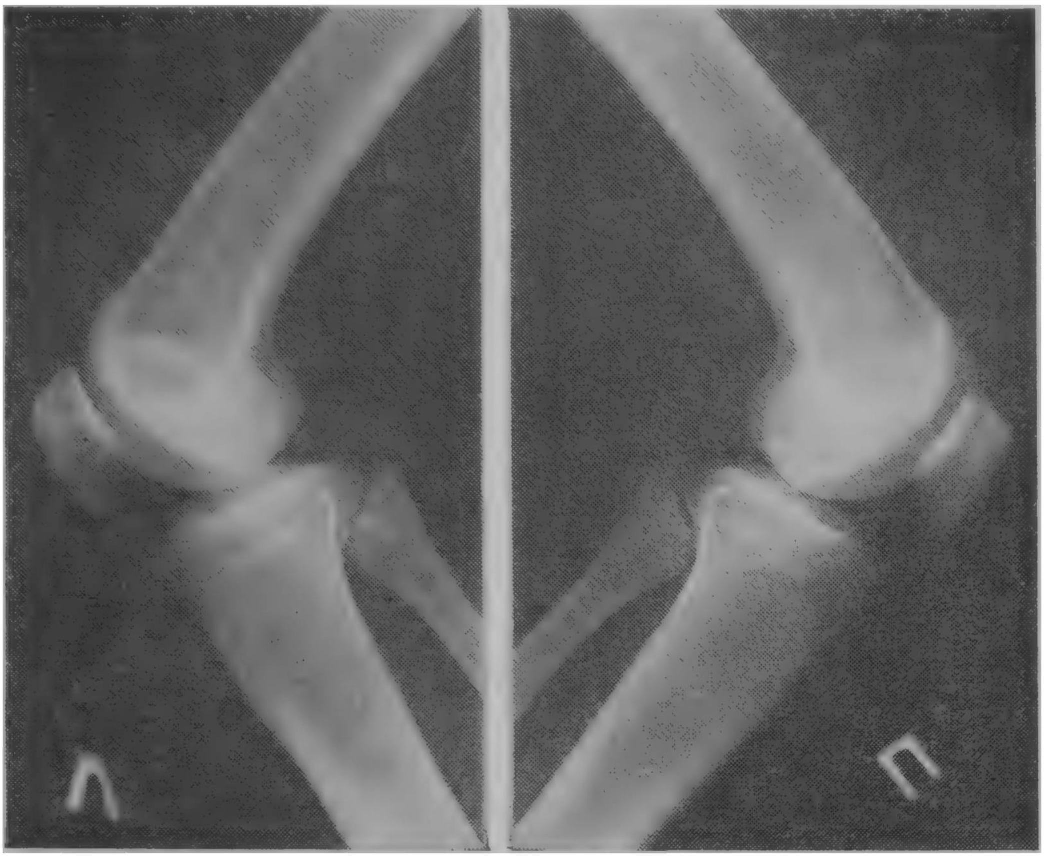

Fig. 3. Knee osteoarthrosis deformans without severe bone abnormalities; Л-left, П-right.

by Tsarfis, Arypaeva, Kopyeva, and Arutyunov, have helped to define clinicomorphological characteristics and to draw up a concept of the degenerative process, centering around the adaptive-trophic dysfunctions of the sympathetic nervous system.

A clinicomorphological classification of deforming osteoarthrosis proposed by Tsarfis (1971) identifies three stages of the disease.

The first, or early, stage is observed in patients showing rapid fatigue of the legs, especially after physical strain, slight locomotor dysfunctions, moderate restriction of movement, and mild muscular hypotrophy. Serum cholesterol and beta lipoprotein levels are slightly elevated, and mild subchondral sclerosis and joint slit narrowing are seen by X-rays (Fig. 3). Morphologically, sclerosis of the superficial synovia and mucoid swelling are noted. Parietal cells are arranged in 1-2 chains, synovial cells are flattened at some sites. Accumulation of collagen fibres, moderate numbers of blood vessels and scarce cellular constituents are seen in the subsynovia.

The second, or advanced, stage is characterized by greater pain syndrome, especially during movements or weather changes. The patients show joint crepitation, locomotor impairment, induration of the joint capsule, and muscular hypotrophy. X-rays show pronounced

Fig. 4. Knee osteoarthrosis deformans in advanced stage.

Fig. 5. Morphological abnormalities of the synovial membrane in advanced osteoarthrosis deformans

subchondral sclerosis, pointed intercondylar tubercles, marked joint slit narrowing, osteophytes, induration of soft tissues and the patellar ligament proper (Fig. 4). Morphological examination of the synovial membrane shows pyknotic synovial cells located at certain distances from each other. The subsynovia had scanty numbers of vessels and cell constituents, its deeper layers contain hard fibrous tissue; vascular walls are thickened and hardened (Fig. 5).

The third, or chronic, disease stage is typified by numerous neurotic complaints, significant joint pain both during movements and at rest, occurring primarily at night or during walking upstairs and downstairs, and flexion extension crepitation. More joints are affected; they are often deformed, and locomotion is strongly impaired. Apart from multiple abnormalities of large joints, there are degenerative changes in the vertebrae, intervertebral disks and junctures, ligamentous and muscular system; joint instability appears (unsteadiness of constituents of the joint which may impair its function). X-rays show most pronounced abnormalities in this stage (Fig. 6). There are typical signs of subchondral sclerosis, massive osteophytes, joint deformities, marked narrowing of the joint slit, induration of soft tissues, local calcification, and metaepiphyseal cyst-like formations. Morphologic examination of the synovia shows pronounced degenerative fibrous changes. There are local sclerosis, hyalinosis, and lipomatosis; parietal cells are absent, or they are flattened and clustered, sometimes chained; their nuclei are pyknotic (Fig. 7). Numbers of vessels and cells in the subsynovial layer are greatly reduced. The tissue has homogeneous sites which are highly positive with PAS-staining. These cites become pink or yellow with picrofuchsin staining.

Complex studies show that in each of the mentioned stages, significant and still subtler changes occur in synoviocyte and chondrocyte metabolism, morphologic structure of the synovial membrane, epiphyseal cartilage, vascular and connective tissue elements. Biochemical alterations to a certain degree indicate the course of articular degeneration. Naturally, these complicated processes induced by the mentioned aetiologic factors are not merely local; they are associated with systemic functional alterations.

Purposeful evaluations of the sympatho-adrenal function, metabolite storage patterns and lysosomal enzyme activity in patients have important pathogenetic and clinical implications. Analysis and comparison of these data with morphologic and cytophotometric findings enable a better understanding of the pathogenesis of osteoarthrosis deformans and mechanism of action of physical methods of treatment employed.

Studies on the sympatho-adrenal function have revealed alterations both in clinical parameters and in catecholamine excretion (Table 1).

Fig. 6. Osteoarthrosis deformans, chronic stage. Secondary synovitis.

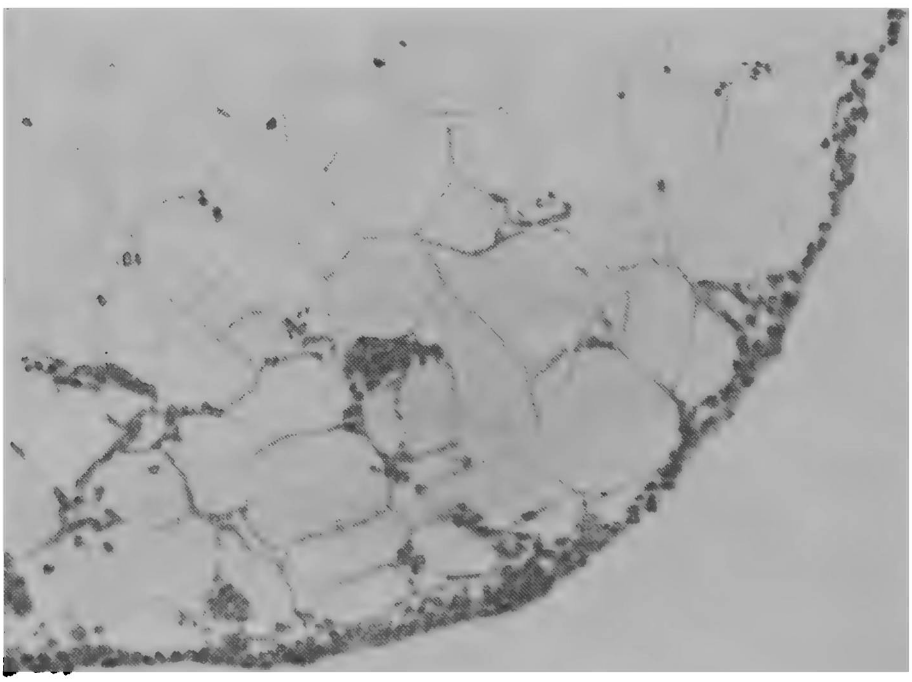

Fig. 7. Chronic osteoarthrosis deformans. Lipomatosis of the synovia, strong reduction and flattening of parietal cells.

Table 1. Alteration of Catecholamine and DOPA Levels in 24-Hour Urine in Patients with Various Stages of Osteoarthrosis Deformans

Disease stage	Number of normal subjects and patients	Catecholamine and DOPA excretion (μg/day)			
		Adrenaline	Noradrenaline	Dopamine	DOPA
Early	88	3.45±0.15 P < 0.05	12.1±0.3 P < 0.01	228±5.1 P > 0.01	23.11±0.38 P < 0.05
Advanced	84	3.28±0.1 P < 0.01	11.3±0.24 P < 0.02	214.3±3.8 P < 0.001	22.5±0.7 P < 0.05
Chronic	65	3.18±0.1 P < 0.02	11.1±0.2 P < 0.01	210±4.5 P < 0.001	21.1±0.4 P < 0.05
Total	237	3.3±0.1 P < 0.02	11.5±0.23 P < 0.002	227±4.5 P < 0.001	22.2±0.4 P < 0.05
Normal subjects	55	3.8±0.14	13.8±0.61	259.8±4.58	24.4±0.5

The above data indicate that a reduction in catecholamine levels occurs at the early stage of the disease. As the dopaminergic link of the sympatho-adrenal system is impaired, dystrophic process intensifies, trophism and stability of the bursoligamentous system are lower, rates of minor injuries of cartilages and large menisci are higher.

Trophism of blood vessels is deleteriously affected, too, by the reduction in sympatho-adrenal mediator levels (Kiselev, Volkova, 1981).

Patients with stage I disease were found to suffer from inadequate blood filling of great vessels of the extremities at projected sites of degenerative joints, as indicated by a statistically significant ($P < 0.001$) decrease of the rheographic index (RI) to 0.039 ± 0.002 ohm, the norm being 0.042 ± 0.001 ohm. Tonic tension of the vascular wall tended to be increased, as indicated by the a/T ratio of 14.5 ± 0.5 per cent ($P < 0.05$), the norm being 13.3 ± 0.1 per cent. Anacrotic values were increased to 0.125 ± 0.001 sec ($P < 0.001$) (the norm is 0.12 ± 0.001). These findings suggest a reduced elasticity of the arterial wall. The catacrotic phase of the β-curve tended to increase to 0.78 ± 0.03 sec (the norm being 0.75 ± 0.01), indicating an impairment in venous blood outflow. Visually, the curve had a rounded top and shallow dicrotic wave located in the middle of its descending slope. The dicrotic index was 0.017 ± 0.001 ohm.

In stage II disease, a greater reduction is observed in catecholamine levels and the rheographic index. The latter was 0.032 ± 0.002 ohm ($P < 0.001$). It was indicative of lower blood filling

at the tested site. Anacrotic values increased to 0.13 ± 0.001 sec ($P < 0.001$), catacrotic ones decreased to 0.76 ± 0.04 sec. The α/T ratio rose to 14.3 ± 0.12 ($P < 0.05$). Pulse wave speed increased to 0.23 ± 0.001 ($P < 0.05$), the norm being 0.24 ± 0.001.

In stage III disease, there was a further decrease in catecholamine levels and the rheographic index (to 0.03 ± 0.001 ohm; $P < 0.001$) and prolongation of the anacrotic phase of the curve to 0.13 ± 0.001 sec ($P < 0.001$), which indicates an ongoing loss of vascular wall elasticity; the α/T ratio rose to 15.4 ± 0.32 ($P < 0.01$). The pulse wave speed increased to 0.21 ± 0.001 ($P < 0.05$). These findings suggest a greater increase in vascular wall tension, lower wall elasticity, and blood depletion in the tested area. The curve shows a plateau-like top, and has no dicrotic waves in its catacrotic segment. Qualitative and quantitative characteristics of the obtained rheographic curves indicate increased tone of great vessels of the extremities at projection sites of knee and other joints and of the synovial membrane vessels and epimetaphyseal bone segments. These alterations seem to be of atherosclerotic origin.

A positive correlation has been found out between low adrenaline and noradrenaline levels and the low rheographic index at the target site ($r_1 = 0.24$, $r_2 = 0.28$), while negative correlation has been found between the daily urinary catecholamine excretion and the α/T ratio ($r_3 = -0.27$) (Buzova, 1982).

The pattern of electrolyte levels in blood serum (Table 2) is of particular interest.

A statistically significant increase in serum sodium concentrations in patients with stages I and III of the disease to 145 ± 2.0 μEquiv/l

Table 2. Electrolyte Levels (Sodium and Potassium) in Blood Serum of Patients with Various Stages of Arthrosis Deformans

Disease stage	Number of patients	Electrolytes (μEq/l)	
		Sodium	Potassium
1	50	139±1.1 $P < 0.05$	4.3±0.1 $P > 0.05$
2	47	145±2.0 $P < 0.05$	4.3±0.05 $P < 0.05$
3	48	145.9±2.6 $P < 0.05$	4.26±0.14 $P > 0.05$
Normal subjects	10	138±1.5	4.5±0.07

r_1 for sodium (rheographic index) = 0.24
r_2 for sodium (rheographic index) = 0.27

($P < 0.05$) and 145 ± 2.6 μEquiv/l ($P < 0.05$) (the norm is $138 \pm$ ± 1.5 μEquiv/l) and a tendency of potassium level reduction indicated abnormal tissue osmolarity: lower osmotic pressure of blood and higher peripheral vascular resistance. As a consequence of these changes the 'basal' component of vascular tonus increased.

Disturbance of central, myogenic and metabolic regulation of the peripheral circulation causes blood depletion in synovial vessels.

An inverse correlation had been established between the increased serum sodium levels in patients and the lowered RI of the rheographic curve at projection sites, for instance, knee-joints. Correlation coefficients were $r_1 = -0.24$ and $r_2 = -0.27$.

Lipid accumulation is amplified by metabolic disorders in the vascular wall. Statistically significant elevations of cholesterol and β-lipoprotein serum levels have been found in patients with all stages of the disease, and are especially prominent in patients with stages II and III of the disease. A negative correlation has been established between lipid metabolism and daily urinary catecholamine excretion (r_1 for adrenaline-cholesterol was -0.18, r_2 for adrenaline-β-lipoproteins was -0.14); a positive correlation has been revealed between sodium and cholesterol levels in blood serum (r_3 for sodium-cholesterol was 0.24, and r_3^2 for sodium-β-lipoproteins was 0.37). These findings show that depressed production of sympatho-adrenal mediators in patients of this group is accompanied by higher serum levels of cholesterol and β-lipoproteins. Thus, the impairment of the adaptive-trophic function of the sympathetic nervous system causing degenerative process in the joints also seems to affect the neurohumoral mechanism of lipid metabolism regulation. Lipid accumulation in the vascular wall aggravates its trophic impairment, reduces the elastic properties of vessels, and narrows the lumina. It results in a greater peripheral vascular resistance and partial oxygen pressure causing significant vasoconstriction.

The impairment in the transport of energy and formative materials leads to the destruction of protein-polysaccharide complexes in the connective tissue of the synovial membrane and cartilage. A statistically significant elevation of serum hexose levels and a tendency of elevation of seromucoid levels have been revealed. This indicates the destruction of carbohydrate-containing polymers which represent intermediate links between glycosaminoglycans and hyaluronic acid.

Abnormal trophism of the intercellular substance of the connective tissue in the synovial membrane and cartilage causes an increase in daily urinary oxyproline level. Thus, oxyproline levels are $43.1 \pm$ ± 7.3 and 49.5 ± 5.6 mg/day ($P > 0.05$) in patients with stages II and III without secondary synovitis (the norm is 34.7 ± 4.2 mg/day); only in stage III do they reach 64.04 ± 12.8 mg/day ($P < 0.05$). Secondary joint synovitis and proliferative changes in synovial tis-

sues are associated with significant elevation in daily urinary oxyproline excretion—to 64.9 ± 11.6 mg/day ($P < 0.05$).

Assessment of levels of serum trace elements in patients with different stages of arthrosis deformans is required for a better understanding of pathogenetic determinants of joint degeneration. Alterations in trace elements levels have been correlated with dynamics of sympatho-adrenal mediator levels and with serum sodium and calcium levels, products of connective tissue metabolism, carbohydrate polymers, hexose, and oxyproline.

A correlation has been revealed between the levels of serum trace elements and the severity of joint degeneration.

A significant imbalance in serum levels of trace elements has been observed, with a marked increase of copper and aluminium concentrations in sera of patients. The imbalance is greater in patients with stages II and III of the disease.

The higher serum copper levels in patients with arthrosis deformans may be viewed as a break in the bond between a metal ion and protein component—an enzyme whose activity depends on the presence of copper ions as specific metal activators of the enzyme (on the other hand, copper ions are inactivated as their bonds with the enzyme are disrupted). There is a reduction in the activity of amino oxidases catalyzing conversions of highly active biogenic amines (adrenaline and noradrenaline) and in the synthesis of citochrome oxidases and ceruloplasmin. Biologic oxidation processes in tissues are impaired because of depressed activity of the mentioned enzymes. The increased serum copper levels in patients with arthrosis deformans seem to be associated with depressed activity of copper-containing enzymes of the cytoplasm of synoviocytes, chondrocytes and connective tissue cells involved in redox processes. Thus, the increase in copper levels in stage I disease was slight (136.4 ± 2.2 μg%, the norm being 126 ± 4.2 μg%) ($P > 0.05$) and energy produced by catalytic reactions involving copper-containing enzymes was sufficient for metabolic activity and regeneration of affected cells, whereas a more substantial increase in serum copper levels was observed in stages II and III of the disease: respectively, $142.9 \pm$ ± 6.9 μg% ($P < 0.05$) and 153.1 ± 4.8 μg% ($P < 0.01$). The higher the serum copper level, the greater is the degeneration in the joints. A highly negative correlation has been found between the reduction in adrenaline and noradrenaline levels in 24-hour urine and the elevation in copper levels in sera of patients ($r_1 = -0.36$; $r_2 =$ $= -0.37$); a positive correlation has been established between sodium and copper levels in blood serum.

There are similar changes in serum aluminium levels. In arthrosis deformans of stage I, the copper levels reach 146.5 ± 5.7 μg% ($P < 0.01$), while in stages II and III they rise to 157.7 ± 5.2 and 162.5 ± 4.4 μg%, respectively ($P < 0.001$). Activity of the mentioned

enzymes and metabolic regenerative ability of cells are lower and degeneration in the joints is more severe with the rise of aluminium level in the blood serum.

There is a tendency of elevation in serum nickel concentration in patients with stages I and II of the disease, respectively to 23 ± ± 2.8 μg% ($P < 0.05$) and 26 ± 1.7 μg% ($P > 0.05$) as compared to the normal value of 21.4 ± 3.4 μg%; the increase is more marked in stage III of the disease: 28.1 ± 1.5 μg% ($P > 0.05$). It indicates lower activity of dehydrogenase, succinate dehydrogenase and glycerophosphate dehydrogenase which inhibit the synthesis of macroergic phosphorus compounds and decrease redox processes in the tissues of joints. The increase in serum nickel concentration indicates a significant degenerative process in the joints.

Serum levels of copper, aluminium and nickel may be used as markers of the severity of degeneration in the locomotor system and markers of metabolic disturbance of synovial and lining cells, chondrocytes, connective tissue cells, and endothelial cells of the blood-synovia barrier.

While copper, aluminium, and nickel are trace elements involved in catalytic reactions, silicon and manganese have formative functions (they are involved in cell building).

A marked imbalance in serum levels of trace elements (aluminium, copper and nickel) with an increase in these levels indicates decreased activity of metal enzymes participating in redox processes of cells and synovial tissues, as a result of which metabolic activity of different cells is lowered. Activity of metal enzymes is impaired and blocked by the imbalance of copper, aluminium, and nickel. It results in abnormal biologic oxidation and eventual energy deficit. In addition, patients with degenerative disorders in joints tissues develop severe deficiencies of silicon and manganese which participate in the biosynthesis of protein-polysaccharide complexes and collagenic structures of the synovial and cartilaginous connective tissue. Comprehensive evaluation of evidence obtained shows that tissue trophism is impaired as the metabolism of trace elements and the lysosomal enzymes are altered. The more severe the clinical course, the stronger is the impairment.

It was important to find out whether a relationship exists between the severity of joint degeneration and the pattern of accumulation of metabolites, in particular proteoglycan-like compounds, in blood serum. For this purpose, total values of proteoglycan-like compounds were compared with their serum fractions in patients with different stages of the disease (Table 3).

The data of Table 3 indicate that serum levels of proteoglycan-like compounds were increasingly higher as the disease progressed and degenerative abnormalities in structural elements of joints intensified. The increase was especially prominent in the levels of total metabo-

Table 3. Blood Serum Levels of Proteoglycan-Like Compounds in Patients with Different Stages of Osteoarthrosis Deformans

Disease stage	Serum levels of proteoglycan-like compounds (mg%)			
	Total	Fraction 1	Fraction 2	Fraction 3
Early	18.5±1.1 $P<0.05$	8.8±0.4 $P<0.001$	7,1±0.4 $P<0.05$	2.6±0.2 $P<0.01$
Advanced	23.6±1.0 $P<0.001$	11.0±0.7 $P<0.01$	8.7±0.4 $P<0.02$	3.3±0.3 $P<0.05$
Chronic	33.1±0.8 $P<0.001$	18.3±0.9 $P<0.001$	11.4±0.5 $P<0.001$	4.0±0.3 $P<0.05$
Total	25.9±0.9 $P<0.001$	13.1±0.4 $P<0.01$	8.7±0.2 $P<0.01$	3.1±0.1 $P<0.05$
Normal subjects	13.5±1.0	3.3±0.5	6.8±0.5	3.4±0.3

lites, fractions 1 and 2. The values of metabolite fraction 3 deviated less from the norm.

Evaluation of the findings indicates that the activity of lysosomal enzymes is greater in severe degenerative process, and the activity of acid phosphatase/proteinase is higher and the activity of leukocyte acid proteinase is lower in a severe clinical course.

It is undoubtedly important to elucidate morphological and histochemical alterations occurring in deforming osteoarthrosis in tissues of the joint, and to explore the relationship between clinical and morphological changes in the synovial membrane and cartilage, and biochemical indices in different stages of the disease.

Histometry and cytophotometry were used in examination of the synovial membrane. Comprehensive assessment of morphological findings suggested atrophic and sclerotic changes in the synovia and epiphyseal cartilage, their manifestations dependent on the stage of the disease.

In early stages of arthrosis established clinically and by X-rays, there is a change in volume proportions of the structural elements of the synovial membrane: synovial cells are reduced in size nearly 2-fold, and numbers of cells in the subintimal layer are increased by 0.48 vol% and those of vessels by 2.3 vol%. There are greater sites of sclerosis, hyalinosis, and lipomatosis. As the degenerative process evolves, especially in the chronic stage, synovial cell sizes are reduced 7-fold, numbers of subint mal cells 2-fold, and numbers of vessels 4-fold. Sites of sclerosis enlarge by 5.5 vol%, hyalinosis by 2 vol%, and lipomatosis by 1.42 vol%. The severity of atrophy and sclerosis is represented in Fig. 8.

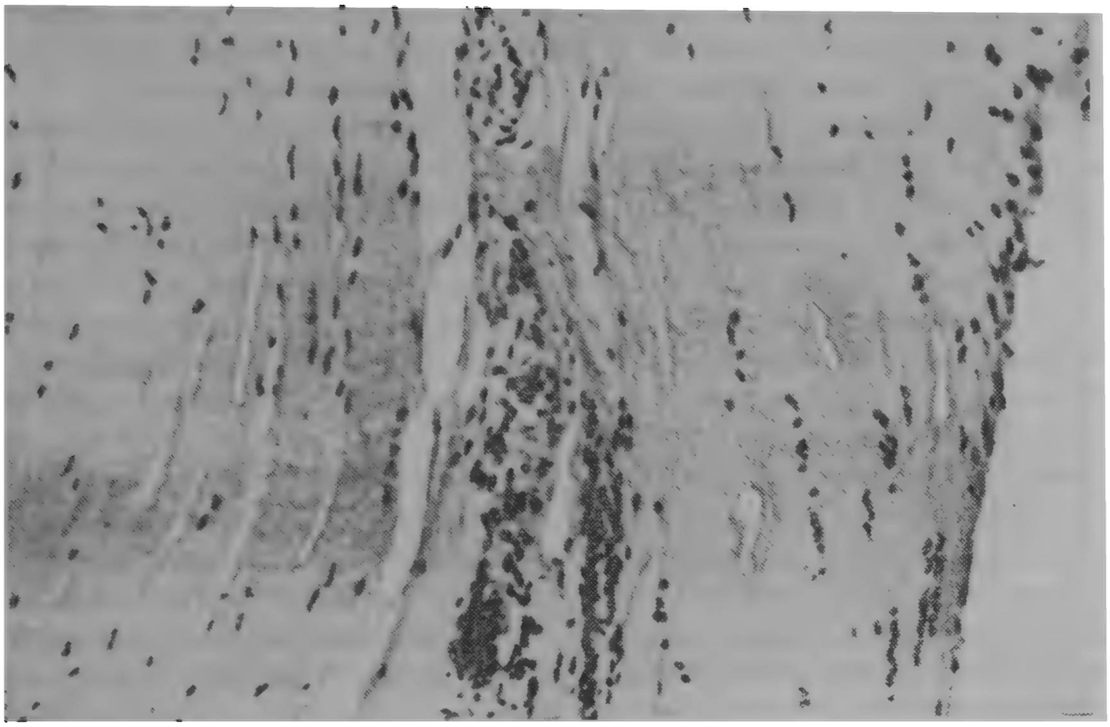

Fig. 8. Osteoarthrosis deformans, early stage.
Severe fibrosis of the synovia, parietal cells are significantly reduced or absent. Dense collagen fibres are seen.

Synovial layer thickness is significantly changed by the evolving degenerative process: early in the disease the thickness is decreased nearly 2-fold, in the advanced stage 5-fold, and in chronic stage 9-fold. The changes in the synovial layer thickness are fewer at proliferative sites, although the layer was found to be 3 μm less in the advanced stage as compared to the early one.

Significant vascular and interstitial sclerosis was also seen in the fibrous capsule. No reliable correlation could be established between the severity of atrophy and sclerosis and the duration of the disease in patients with early stages. It was found, however, that patients showing clinical evidence of atherosclerosis have marked capillary and precapillary sclerotic changes.

In addition, moderate activity of acid phosphatase and PAS-positive granules, showing slight metachromasia at toluidine blue staining, were observed.

Histometric and cytophotometric analysis using the Avtandilov method revealed no significant differences in structural and enzymochemical properties of vessels, as compared with those of the normal tissue ($P > 0.05$).

Findings of great interest have been obtained via histomorphologic and histoenzymochemical examination of the epiphyseal cartilage in patients with early stages of osteoarthrosis deformans. The

studies have shown that in most cases the thickness of the articular cartilage began to be reduced already in the early stage, although all four segments of the epiphyseal cartilage remained intact.

Most chondrocytes had glycogen, glycoproteins and highly active lactate dehydrogenase in their cytoplasm. Chondrocytes showed pyknotic vacuolized cytoplasm with abundant lipids and glycoproteins.

The intercellular substance of the cartilage (matrix) in the majority of visual fields had a homogeneous appearance when stained with haematoxylin and eosin. Cell proliferation with chondrocyte clustering was determined at cartilage-adjacent sites already in the early stage of osteoarthrosis deformans. No significant changes were noted in deeper epiphyseal segments.

It should be stressed that it is fractions 1 and 2 that primarily account for the increase in blood serum levels of proteoglycan-like compounds. This gives grounds to consider that the mentioned morphologic abnormalities develop not only in large joints but also in intervertebral disks and junctures, since further studies have demonstrated that fraction 2 of proteoglycan-like compounds was as a rule enhanced in blood serum in the presence of obvious intervertebral X-ray abnormalities.

Similar methods were used in the search for a correlation between morphological and biochemical shifts in progressive deforming osteoarthrosis with special attention paid to its advanced stage. Morphologic examinations of the synovial tissue obtained by knee-joint puncture biopsy in patients showing clinical and X-ray evidence of advanced osteoarthrosis deformans revealed greater atrophic and sclerotic synovial alterations, as compared with those in the first group of patients.

Comparison of clinical, biochemical and morphological findings have demonstrated a correlation between histologic and histoenzymochemical disorders in the synovial membrane, accompanying the evolution of the disease. In 20 patients of this group with a five-year history of the disease, synovial cells were found only on half of the synovial membrane surface. Examination of the synovia consistently showed small sites of proliferating synovial cells arranged in four-five layers.

The subintimal tissue at the sites of synovial cell proliferation was represented by epithelioid cells showing moderate lactate dehydrogenase and low succinate dehydrogenase activity. Small focal perivascular lymphoid-macrophage infiltrates were occasionally observed.

Small cube-shaped synovial cells were revealed in 22 patients with advanced osteoarthrosis deformans of 5 to 10 year duration. Depressed redox enzyme and acid phosphatase activity in the cells was revealed by using the above methods. The subintimal tissue showed severe capillary blood depletion and diffuse sites of sclerosis, hyalinosis, and lipomatosis.

In patients with advanced arthrosis deformans, the structure of the epiphyseal cartilage was simultaneously examined, and histomorphologic and enzymochemical alterations of the synovial membrane were compared with those of the epiphyseal cartilage and clinical and biochemical findings. The thickness of the articular cartilage was decreased because of the actual disappearance of the superficial area and destruction of cellular elements of the 2nd segment of the cartilage tissue. The surface of the epiphyseal cartilage exhibited multiple slits and caries (Fig. 9). Remaining chondrocytes had pyknotically changed nuclei. The intercellular substance lost its homogeneity and basophilia, and had a granular and fibrillar appearance. Metachromasia was no longer observed, and PAS test was largely negative (Fig. 10). Most cells were intact in the 3rd and 4th segments of the cartilaginous tissue, although some cells showed degenerative changes and nuclear pyknosis. Matrix metachromasia and PAS test of the basic substance were moderately decreased. The more pronounced the degenerative process in the joints, the higher is the activity of lysosomal enzymes and the levels of proteoglycan-like compounds in serum. A relationship has been found between the elevation of copper, aluminium and nickel levels and the reduction of redox pro-

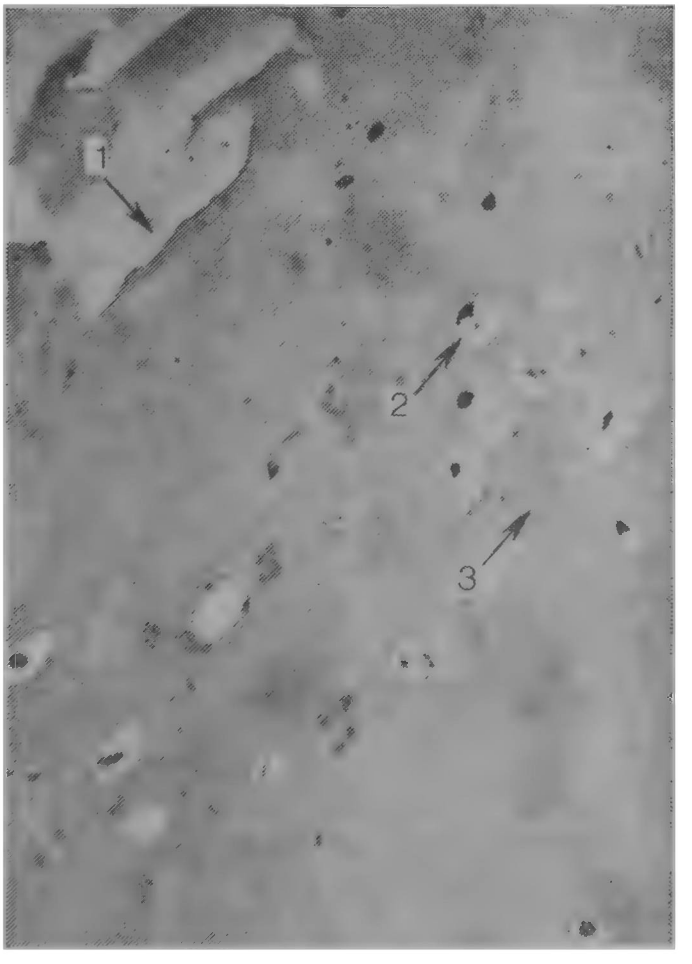

Fig. 9. Alteration of the epiphyseal cartilage in the advanced stage of osteoarthrosis deformans:

1—significant superficial caries; *2*—strongly reduced chondrocyte counts; *3*—intercellular basic substance is granular or soft fibrillar. Haematoxylin and eosin; × 200

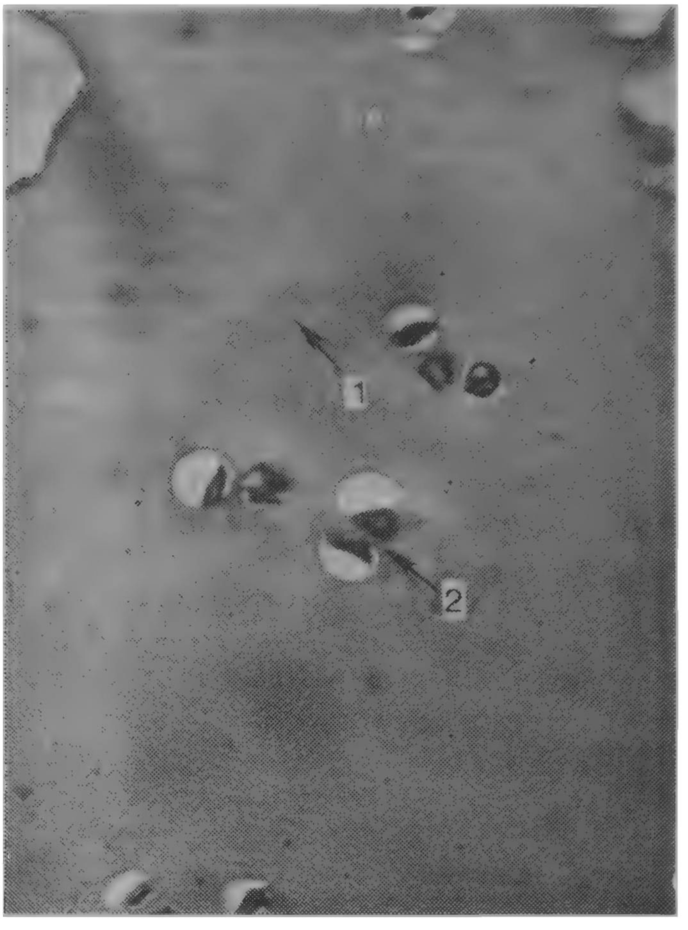

Fig. 10. Advanced stage of osteoarthrosis deformans:
1—highly negative PAS test in the cartilaginous basic substance; *2*—small sites of chondrocyte proliferation. PAS test; × 200

cesses in cells. Reduction in manganese and silicon levels affects the synthesis of polysaccharide complexes and collagenic structures of the connective tissues. Biochemical studies have demonstrated a reduction in daily urinary excretion of adrenaline, noradrenaline and dopamine ($P < 0.05$).

The discussed results indicate that the decreased activity of the hormonal and mediator links of the sympatho-adrenal system is associated with progressive degeneration in the joints. In these patients clinical and X-ray studies showed skeletal muscle hypotrophy and destructive changes in bones and epiphyseal cartilage of affected joints. In addition, fibrous alterations of the capsule and ligamentous system of joints and locomotor dysfunction were verified by clinical and goniometric methods.

These processes were still more manifest in severe chronic diseases. Clinicomorphological studies in 25 patients have shown that severe sclerotic and atrophic changes were present in the synovial membrane (Fig. 11). Synovial cells were detectable in limited areas, and cytophotometry showed a reduced synovial cell layer. These cells were smaller than those of the early stage. Lactate dehydrogenase and acid phosphatase activity, and that of the enzymes of tricarboxylase and pentose cycles were decreased.

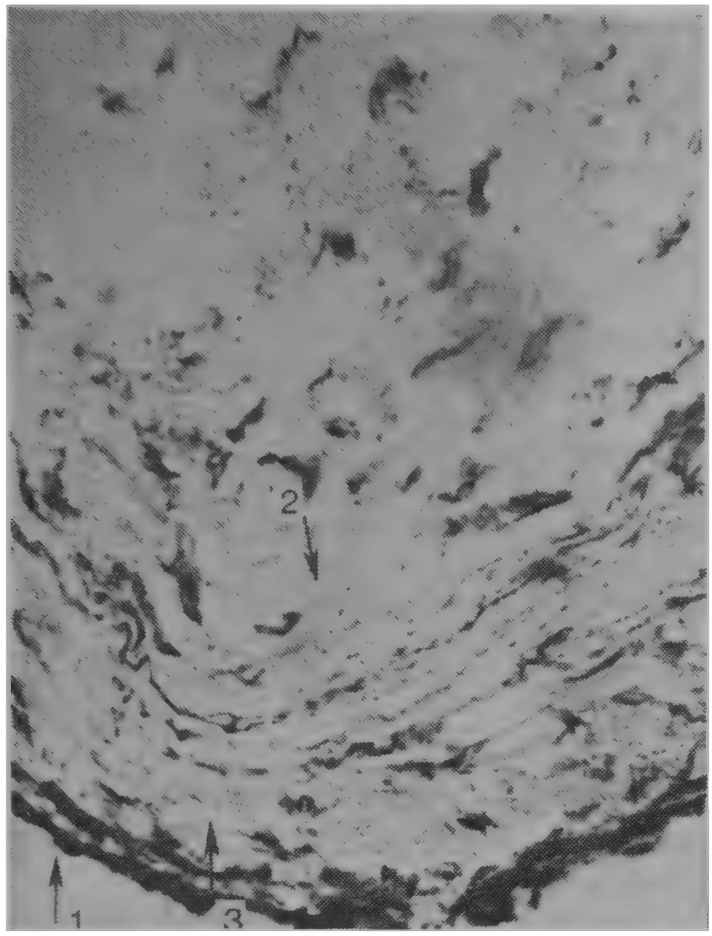

Fig. 11. Morphological abnormalities of the synovia in chronic osteoarthrosis deformans:

1—synoviocytes are absent; 2—severe sclerossi; 3—hyalinosis of the subintimal tissue. Haematoxylin and eosin; × 200

Degenerative cartilaginous processes in patients with chronic osteoarthrosis deformans are largely dependent on synovial sclerotic changes and osteosclerotic lesions in metaepiphyseal segments of the bones making up a joint. Even partial obliteration of capillaries in the epiphysis considerably affects the nutrition of the 3rd and 4th segments of the epiphyseal cartilage, since it severely impairs osmosis and diffusion which are actually a solitary pathway of energy and formative supply of chondrocytes and cartilage matrix. These patients experience a characteristic severe decrease in catecholamine levels and sharp trophic disorders of the skin, muscles, and locomotor dysfunction. X-rays show obvious abnormalities manifested as subchondral osteophytes, sclerosis of the epiphyseal segments, calcification of joint ligaments, femoral muscles, etc.

The increase in serum acid phosphatase and acid proteinase activity is especially prominent. As lysosomal enzyme activity in serum increases, the quantities of proteoglycan-like compounds in it become increasingly greater.

Clinical and X-ray studies have demonstrated degenerative changes in various intervertebral segments, primarily cervical and lumbar, in 49.1 per cent of our patients with osteoarthrosis deformans.

This fact provides an additional evidence that alterations in the tone and reactivity of the vegetative nervous system, including those in sympathetic fibres, lead to degenerative changes in intervertebral disks and junctions, similar to those occurring in large joints. The difference, however, lies in that lesions of the disks and intervertebral junctions result in spondyloarthrosis, diskogenic radiculitis, and radiculoneuritis which complicate the clinical course of joint degeneration. Hypotrophy of skeletal muscles, skin and its appendages becomes more pronounced, and the tone of great vessels, primarily those of the legs, and the blood-filling of the distal parts of feet are reduced; skin sensitivity is impaired.

Apart from these clinical features of osteoarthrosis deformans, there is secondary synovitis as a complication of the dystrophic process. Clinical diagnostic criteria for secondary synovitis have been adequately defined, whereas characteristics of morphological disorders established by cytophotometry have not been determined so far. Pain and locomotor dysfunction are the major complaints which make patients with deforming osteoarthrosis seek medical aid. Most often pain initially occurs while going upstairs or downstairs and subsequently at rest, predominantly at night. The patients display X-ray abnormalities (caries, osteophytes, local sclerosis, epiphyseal cysts, etc.), increased ESR, higher serum levels of C-reactive protein and sialic acids.

Opinions vary on what morphological shifts occur in the synovial membrane in secondary synovitis. For investigation, biopsy specimens of the knee-joint of patients showing clinically manifest secondary synovitis were examined.

Histomorphologic and cytophotometric studies have enabled the differentiation of several sites in the synovial membrane: that affected by active inflammation, that in which the inflammatory process is regressing, and that affected by predominant sclerosis and lipomatosis. Histologic examination of the synovial tissue showed that different synovial sites have characteristic cellular structures with distinct inflammatory elements; sites of marked atrophy and sclerosis are seen in synovitis.

Furthermore, small fibrinous deposits on the synovial membrane surface and local fibrinoid changes are detected in the subintimal tissue (Fig. 12).

Only clinical and X-ray comparison of major manifestations of rheumatoid arthritis and deforming arthrosis and differentiated analysis of histomorphologic and histoenzymochemical findings by the Avtandilov morphometric method enable an accurate diagnosis and elucidation of the nature and degree of cell structure alterations in organs, cellular, and subcellular levels.

Thus, comprehensive histochemical and histoenzymochemical studies of synovial membrane tissues and articular cartilage during

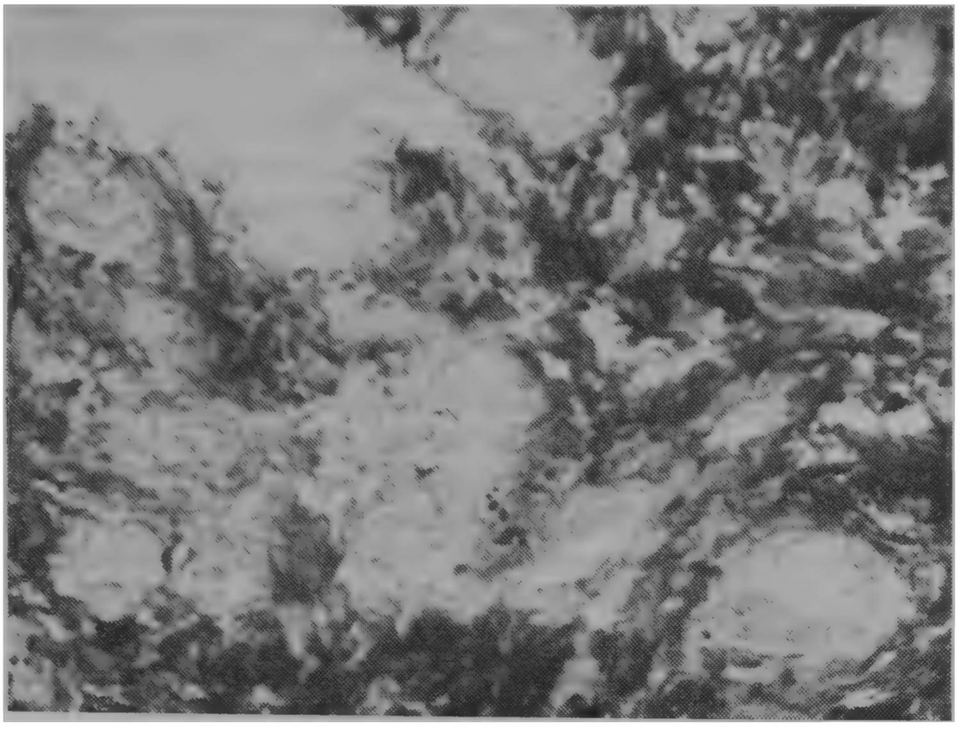

Fig. 12. Secondary synovitis with a high alkaline phosphatase activity at the site of exacerbation.
Isodye test for alkaline phosphatase; × 200

different stages of osteoarthrosis deformans, and a comparison of the results with clinical and biochemical findings help clarify the nature of the pathogenesis.

Cortical disorders, alterations in the tone and reactivity of the vegetative nervous system and inhibition of the adaptive-trophic function of the sympathetic nervous system are induced both in the old and the young by poor working and living conditions, especially by physical overstrain, continuous microtrauma, and sequelae of various diseases. In turn, these abnormalities affect adaptive functions and neurovascular regulation, primarily in the microcirculatory system where capillary and precapillary obliteration occurs. The resultant disorders in the transport of formative and energy substances, hormones, electrolytes, trace elements, oxygen, and delayed metabolite evacuation (due to dysfunction of venous and lymphatic capillaries) lead to accumulation of intermediate metabolic products, primarily acid, disturbance of cellular metabolism and intensification of the degenerative process in synoviocytes, subsynovial cellular structures, vessels, etc. These metabolic disorders affect local trophic processes, resulting in cell degeneration, scarring, local sclerosis and lipomatosis of the synovial membrane. The secretory function of the synovial membrane is sharply affected by these disorders: the quantity of synovial fluid is lessened, its physicochemical prop-

erties are altered, enzymic functions impaired, and sclerotic processes intensified. Metaepiphyseal small vessels are emptied, and atrophy of bone cellular constituents occurs. The above changes cause trophic impairment of the epiphyseal cartilage which, devoid of vessels and nerves, is nourished, according to laws of osmosis and diffusion, by the synovial fluid, formative and energy substances coming from the epiphyseal microcirculatory system. In the presence of these severe morphological and functional disorders, frequent minor injuries and a lower resistance of the cartilage cause breaks in lysosomal membranes and the release of proteolytic enzymes into intercellular space, as a result of which the activity of acid proteinases enhances. Active proteinases induce proteoglycan depolarization with formation of small protein-polysaccharide complexes leaving the epiphyseal cartilage. These alterations form the basis of proteoglycan deficiency of the fundamental substance in the epiphyseal cartilage.

As a result, the degenerative process progresses, which is determined both clinically, by X-rays, histomorphologically, cytophotometrically, and cytoenzymochemically.

Therefore, histometric and quantitative histoenzymochemical analyses indicate impairment of the synovial cellular metabolism, depletion of the microcirculatory bed, and atrophy of elements in the organs, responsible for glycoprotein synthesis. These processes lead to a sharp decrease in the secretion of synovial fluid and poor resorption of decomposition products.

Complicated functional and morphological alterations initially occurring in the synovial tissue have deleterious effect on metabolic-trophic and biochemical processes in the epiphyseal cartilage. Histochemical and histoenzymochemical studies of different sections of the cartilage have shown that nutrition of chondrocytes, connective-tissue fibres and intercellular substance is strongly impaired by the mentioned processes. Severe dystrophic disorders are induced by the trophic impairment in the matrix and, subsequently, epiphyseal chondrocytes. These data show that significant destructive lesions in the cartilaginous tissue and morphological disorders in the synovial membrane develop in deforming osteoarthrosis of different stages. Advance of the disease is associated with gradual impairment of the segmental structure of cartilage. As discussed above, its early involvement is characterized by a total reduction and nonuniform distribution of acid mucopolysaccharides (chondroitin sulphate and keratin sulphate) in the 1st and 2nd segments, which ensure significant elasticity of the cartilage and its resistance to mechanical load.

Effect of Iodobromine Baths and Decimetre Waves on Arthrosis Deformans

Patients with different stages of arthrosis should be treated at resorts where iodobromine waters are available per se or iodine and bromine are contained in sodium chloride waters.

In our many years of experience, therapeutic iodobromine waters have come to be defined as waters containing no less than 10 mg/l of iodine and no less than 25 mg/l of bromine

It is known that sodium chloride iodobromine waters influence the body in various ways, but their specific therapeutic effect is determined by active trace elements, such as iodine and bromine.

The recent studies have demonstrated that after bathing the greatest amounts of iodine are found in the thyroid, and those of bromine in the pituitary. During bathing, iodine and bromine enter the internal medium of the body. With the help of radioactive indication Utekhin (1979) and Dubar and Fammerelli (1976) have demonstrated that these trace elements were seen to enter the internal medium through the skin and respiratory tract. Iodine is absorbed not only from the iodobromine bath but also from the air. According to Sadilkova and Nevoral (1979), about 1 mg of iodine and 0.9 mg of bromine enter the body during an iodobromine bath. Iodobromine baths have beneficial effect on the cardiovascular, nervous, and adaptive systems.

Clinical observations have shown an improvement in the general condition, milder neurotic responses (excitability and irritability), and better sleep and disposition in patients treated with iodobromine baths, therapeutic exercises, and massage (complex No. 1). However, skin irritation, itching and allergic rash appeared after 5-6 procedures in 8 per cent of all patients, and disappeared within 2-3 days after decreasing the bath time. These symptoms represented a balneopathologic response which was probably due to iodine or bromine intolerance. Therefore, prescribing the iodobromine baths, the physician must obtain a detailed medical history, so as to foresee such responses and use the adequate therapeutic methods by reducing concentrations of trace elements in the iodobromine water.

The patients received a fasting diet during treatment, which resulted in a 4-8 kg loss of body weight. This had favourable influence on locomotor activity. No effect was noted in patients with advanced and particularly chronic disease, and in persons with arthrosis deformans and secondary synovitis. In these patients both clinical and biochemical responses of arthrosis and secondary synovitis were poor.

Inflammatory activity was more greatly reduced by iodobromine baths, decimetre wave therapy, medical therapeutic exercises and

massage (complex No. 2) than by the iodobromine baths alone. There is less improvement in anterior hypophyseal and adrenocortical function due to iodobromine baths alone than when these baths are used in combination with decimetre wave therapy. The improvement suggests stimulation of the ACTH-producing function of the anterior hypophysis and activation of the synthetic function of the adrenal cortex by hypophyseally absorbed bromine. An increase in the cortisol content per millilitre of blood is favourable for cell membranes. They are consolidated, and inflammatory exudation is reduced. Furthermore, cellular metabolism, capillary circulation in the synovial membrane and its secretory function are enhanced by iodobromine baths. As a result of this, trophism of chondrocytes and connective-tissue reticulum intensifies. The levels of thyrotrophic hormone which is a stimulant of thyroid cells function tend to increase. Absorbed iodine is utilized by these cells as a 'raw material' aiding the elevation of tri-iodothyronine levels, which promotes cellular metabolism and tissue trophism. More pronounced clinical response is observed in patients treated with the therapeutic complex No. 2. Decimetre waves are applied to the affected joints, enhancing blood supply and transport of hormones to the synovial membrane, on the one hand, and exerting direct influence on the affected joint tissues, on the other hand. Therefore, even a small amount of tri-iodothyronine intensifies trophism, increases secretory function of synovial cells, and aids in synovial fluid supply to the epiphyseal cartilage. These facts are quite manifest clinically: pain subsides or disappears, exudation and joint deformations are reduced, and the locomotor function improves.

It is notable that biochemical and radioimmune tests did not change in patients receiving the placebo, although there was some therapeutic effect: lesser pain, better general condition, and increased locomotor function. Such a clinical response was seen in only 49 per cent of all patients; it did not last long after discharge from the hospital. Naturally, sparing of joints, primarily knee and coxofemoral ones, taking place as a result of restricted physical activity in the hospital, and, hence, reduction of minor injuries contribute to alleviation of clinical manifestations of secondary synovitis. However, no change in adaptive functions and activity of the disease was seen in the placebo treatment. Clinical response is especially marked in the early and advanced stages of arthrosis. Apart from physical relief, the response is affected by the psychotherapeutic influence of the physician on the patient, especially as the physician succeeds in demonstrating the success of therapy. It is probably for this reason that trophic processes are not altered and biochemical abnormalities do not disappear, especially abnormal levels of lipids, hexose, C-reactive protein, ESR, and catecholamines.

Only cortical, mainly psychic and sensory activities, are altered

by the psychotherapeutic influence, while adaptive function is not increased enough to be able to 'banish' the degeneration and secondary inflammation of the synovial membrane underlying this disease.

The sympatho-adrenal function is modified by the mentioned therapeutic complexes. Analysis of the presented data indicates that hormonal and sympathetic links of the sympatho-adrenal system are activated by the iodobromine baths. However, the response is smaller in chronic arthrosis and secondary synovitis as compared to that in the early stage of disease. Functional changes of the sympathoadrenal system produced by the iodobromine baths combined with decimetre wave therapy are more marked and parameters of its two links are higher than those obtained by using iodobromine baths alone. In addition, these changes appear to correspond to clinical indices characterizing trophic processes.

There is a correlation between the therapeutically produced increase in 24-hour urinary excretion of adrenaline and noradrenaline and the decrease in serum hexose levels. It suggests that the iodobromine baths and, moreover, their combination with DMW therapy result in lower cell permeability and collagen destruction, higher manganese and silicon levels, and lower serum copper levels, especially in the presence of secondary synovitis. Metabolism of trace elements, including iodine and bromine, is intensified by the factors under scrutiny. This improves trophism and secretion of the synovial membrane, and metabolism of chondrocytes and connective-tissue cells of the epiphyseal cartilage reticulum.

It was of interest to determine how much tissue circulation is modified by the therapeutic complexes since oxygen, energy and formative supply of cells is circulation-mediated.

It was verified in a radioisotope study using xenon that a pretreatment value of blood flow in patients with AD was $1.73 \pm$ $\pm\ 0.14$ ml/min per 100 g of tissue, whereas it rose to 2.11 ± 0.14 ml/min per 100 g of tissue after a course of iodobromine baths concomitant with DMW therapy. The difference between average values was 0.38 ml/min per 100 g of tissue. The statistical processing of the data obtained established the differences between $P < 0.01$ and $P < 0.05$.

In order to elucidate therapy-associated effect of tissue blood flow on the skin temperature, 876 thermograms were obtained. The difference in skin temperature readings prior to and following a course of iodobromine baths was 0.25-0.3 °C. A slightly greater (0.5 °C) difference was seen in patients receiving the iodobromine baths and DMW therapy. These readings are inadequately high to indicate a therapeutic increase in the skin temperature. For this reason, this work gives total thermoasymmetry in knee and ankle areas, and in the area of metatarsal-phalangeal junction of big toe. The

readings, in particular the total and mean thermoasymmetry values, show that total thermoasymmetry was reduced after iodobromine baths by an average of 3.9 °C in all patients with osteoarthrosis deformans (OAD) because of different factors (vegetative, vascular, trophic, etc.). It suggests that, by intensifying the peripheral circulation in the affected joints, the iodobromine baths promote cellular metabolism and abolish asymmetry in degenerated joints. Apart from total values, mean values of thermoasymmetry were evaluated. Statistical processing indicated an increase to 0.93 °C. This implies an approximately 2-fold greater reduction of thermoasymmetry by the iodobromine baths, as compared with that deduced from total thermoasymmetry values.

The difference is even greater in patients receiving the iodobromine baths concomitant with DMW therapy. Following the course of treatment total thermoasymmetry was reduced by 7.7 °C, the mean value being 0.257 °C.

Therefore, a comparison of the results in two groups of patients showed that the second therapeutic complex produced a greater change in thermoasymmetry values than the first. This corresponded to a good clinical response observed in patients.

Along with neurohumoral and neurovascular alterations obtained by a course of iodobromine baths or baths concomitant with DMW therapy, significant changes were observed in the symptomatology of the affected joints. A significantly greater decrease in the severity of pain was obtained by the iodobromine baths and DMW than by the baths alone. The fact is important, since, first, pain was more severe in the second group of patients; second, decimetre waves penetrate into the tissues by 8-10 cm and deeper, thereby intensifying blood supply, especially in metaepiphyseal bone segments and the synovial membrane, restoring oxygen deficiency, and increasing energy and formative supply of joint tissues; third, skin permeability for iodine and bromine is increased, thus increasing absorption of these elements which enhance enzymic processes in cells. Pain reduction by complex No. 1 alleviates joint stiffness. In patients with arthrosis, iodobromine baths alone also contribute to muscular trophism and locomotion. Enhancement of tissue blood flow, formative materials and oxygen transport and metabolite excretion obtained by this therapeutic complex is a basis for metabolism activation and elimination of dystrophy not only in the joints and skin but also in the muscles. This bears great implications for increasing the patients' working ability. There was a decrease in the number of patients with marked pretreatment muscular hypotrophy, and a prominent increase in the number of patients who had no hypotrophy after treatment, all this taking place in 3-4 months following therapy. It was a matter of time and locomotor and trophic improvement.

It was also important to determine the degree of secondary syno-

vitis alleviation. To this end, pre- and post-treatment incidence of synovitis was compared. Therapeutic complex No. 2 effected synovitis much more than iodobromine baths alone. Therapy was less effective in patients with tendon and ligament inflammation. This might be related to the fact that severe degenerative lesions of ligaments and tendon sheaths and their calcification respond poorly to therapy. Nevertheless, a therapeutic effect was obtained in four-fifths of all patients by using complex No. 2.

Iodobromine baths had favourable effect on the phase pattern of the left ventricular systole studied in patients with AD. Intra-phase values—myocardial tension index and intrasystolic index—showed a statistically significant improvement. Greater positive dynamics was obtained by using the second therapeutic complex. In 94 per cent of all patients, the left ventricular phase pattern was modified mainly by prolongation of the tension phase. A course of iodobromine baths and DMW therapy produced alterations in the tension and expulsion phases, although they were statistically significant only in two-thirds of patients. In contrast, there was a statistically significant change in the intra-phase values—myocardial tension and intrasystolic index. These findings suggest that the dystrophic process in the myocardium as a sequela of inhibited adaptive-trophic function of the sympathetic nervous system was considerably decreased by therapy: myocardial trophism, contractile capacity and intracardiac haemodynamics were improved.

It is obvious, therefore, that therapy of patients with AD poses great difficulties. They arise as a result of an inadequate knowledge of the pathogenesis of degeneration, the complexity of the mechanism of secondary inflammatory process in the synovial membrane, and finally, a lack of understanding of therapeutic effect of physical factors.

As the adaptive-trophic function of the sympathetic nervous system is impaired, deleterious environmental factors largely contribute to the first two processes. Because of this impairment, the regulation of blood supply to joint tissues, visceral organs and skeletal muscles is affected. It results in metabolic dysregulation of trace elements and hormones, lower redox potentials and activity of enzyme systems, impaired energy, formative and oxygen transport to joint tissues, and slower excretion of metabolites from degenerated sites of different tissues of joints.

Morphological, cytophotometric and histoenzymochemical studies have demonstrated that initial degenerative disorders occur in the synovial membrane as a result of partial blood depletion of the capillary network, microcirculatory disturbances and lack of energy, formative, trace elements and oxygen supply of synoviocytes, histiocytes, and fibroblasts. These deficits cause disorders in the cellular metabolism of the synovial membrane, its secretory function, and a

reduction of the synovial fluid volume. Similar processes occur in the capillary network of the bone epiphyses. This entails inhibition of trophic processes in chondrocytes and connective tissue cells of the epiphyseal cartilage. It is partially dried up and cracked; there appear cysts, osteophytes, subchondral sclerosis, and joint deformities. These disorders are the cause of joint instability, locomotor dysfunction, and weakening of the bursoligamentous system. All these determinants and accumulation of cell 'debris' in the synovial fluid, becoming antigenic, lead to secondary synovitis complicating the clinical course of arthrosis.

Furthermore, a substantial contribution to the pathogenesis of AD is made by the functional disturbance of the adaptive systems, mainly the sympatho-adrenal system, and by the reduced ability of the anterior hypophysis to produce ACTH and thyrotropic hormone (TTH), resulting in reduction of cortisol, tri-iodothyronine, thyroxine, adrenaline, and noradrenaline. Hormone deficiency concomitant with lower energy, formative and oxygen transport leads to degeneration. Degrees of impairment of these processes have been found to parallel clinical and X-ray indices in each of the mentioned AD stages.

Such an understanding of degeneration has important clinical implications, since it can identify the contribution of a physical factor to the enhancement of the adaptive-trophic sympathetic function, regulation and restoration of impaired functioning of other adaptive systems.

Neuroreflex processes are activated by iodobromine baths. Iodine and bromine absorption occurs simultaneously. Bromine is absorbed by the hypophysis, increasing anterior hypophyseal ACTH- and TTH-producing function. This in turn leads to the elevation of the cortisol level and activation of thyroid cells. Iodine ions entering the internal medium are uptaken by these cells, and tri-iodothyronine and thyroxine synthesis is enhanced. These hormones, as well as corticosteroids, are important for better cellular metabolism. In addition, the steroids inhibit the activity of secondary synovitis. This opinion rests on the observation of a correlation between the increase in steroid levels and the alleviation of clinical syndromes of arthrosis. Besides, hexose and C-reactive protein levels, and ESR appear to decrease. However, iodobromine baths alone in active synovitis cannot correct trophic and inflammatory symptoms of advanced and, particularly, chronic arthrosis. Therefore, therapeutic utilization of DMW of different intensities (35 to 55 W), corresponding to the activity of secondary inflammation in the synovial membrane and epiphyseal cartilage dystrophy, improves the functional activity of the adaptive systems and the clinical course. The immunodepressive effect is intensified and the activity of secondary synovitis is lowered by the DMW-associated enhancement of steroid

metabolism, the release of free hormones, and the depression of transcortin levels. These changes help increase the cellular metabolism in all elements of the joint, including the epiphyseal cartilage. The adaptive-trophic sympathetic function is stimulated more by the iodobromine baths and DMW than by the baths alone. Actively released adrenaline and noradrenaline mediators influence not only the articular tissue trophism but that of the visceral organs: cardiac, vascular, skeletal and smooth muscles, etc.

Critical analysis of the discussed facts enables us to recommend the resort therapy with iodobromine waters for patients with AD of the early and advanced stage. Patients with chronic disease who usually have intercurrent visceral degenerative diseases ought to be sent to the nearest sanatoria, where natural or artificial iodobromine baths are available. Patients with advanced or chronic disease require therapeutic use of DMW.

Contraindications for these mineral waters are bromine and iodine intolerance, acute intercurrent or associated diseases, malignancies, and other diseases precluding physical therapy.

Effect of Sulphide and Radon Baths on Arthrosis Deformans

Clinical studies of many years have shown that significant modification of the adaptive-trophic sympathetic function is induced by sulphide waters. The modification improves the general condition, vigour, vascular dystonia, capillary and precapillary circulation both in arterial and venous branches, and decreases chronic venous insufficiency. Moreover, the clinical course becomes better, joint crepitation is reduced or absent, pain is significantly abated, muscular strength and locomotor function become higher. Even patients with chronic forms of arthrosis deformans begin to move freely, sit down and stand up.

Biochemical studies have shown that a course of sulphide baths causes substantial shifts in serum catecholamine, metabolite and enzyme levels. The adaptive-trophic function of the sympathetic nervous system is promoted by the sulphide baths, which is corroborated by the increase in adrenaline and dopamine levels, and improvement in trophism of the skin and its appendages, synovial membrane, epiphyseal cartilage, increase in skeletal muscle tone, and disappearance of vascular asymmetry (altered pulse rates in the normal and affected extremities). An important role in these processes is played by the reduced activity of lysosomal enzymes which cause depolymerization of proteoglycans, resulting in the formation of smaller protein-polysaccharide complexes; these leave the epiphyseal cartilage and enter the blood serum, accumulating there in high amounts. It is characteristic that the accumulation of metabo-

lites is greater when clinical and X-ray manifestations of the degenerative process are more marked.

The above data suggest that under the influence of sulphide baths significant metabolic and functional changes take place in different adaptive systems. Along with these changes, inflammation activity is diminished or terminated in patients with osteoarthrosis deformans and secondary synovitis.

It must be noted that the significance of these clinical and biochemical findings is even greater when compared with morphological changes following the combined therapy.

Evaluation of morphological and histoenzymochemical alterations after treatment and, more important, 6-9 months later is a requirement for understanding the mechanism of action of sulphide baths and concomitant medical exercises and massage for the discussed disease.

An assessment of the morphology of puncture biopsy specimens taken at various periods following therapy, as studied by Nesterova, has demonstrated that alterations in cellular structure and function of synovial membrane capillaries in 1 month were not as great as those in 6-9 months following therapy. This is natural, for time is an important factor in proliferation evolution, the appearance of microvilli, the activation of the synovial secretion, and the development of biochemical and metabolic effects of combined therapy. Only synovial hyperaemia and a slight increase in synovial fluid quantity are seen immediately after therapy, whereas new microvilli, subsynovial capillaries and pyroninophilia of lining cells appear within 6-9 months.

The change in the synovial morphology after a course of sulphide baths and 9-12 months later is represented in Figs. 13 and 14. Before therapy (Fig. 13) the synovial membrane incorporated the adipose and connective tissue. It displayed only solitary vessels and signs of collagen fibres degeneration accompanied by fibrinoid swelling, pyknosis of connective-tissue cell nuclei, and a significant reduction in numbers and sizes of synovial cells. Nine months later, an increase in numbers of small vessels and intense cellular reactions were observed in the same female patient (Fig. 14). A more marked change was noted in the subsynovial layer, where collagen bundle loosening appeared to be arrested, and the structure of synovial membrane was nearly normal.

Clinico-morphological analysis of pre- and posttreatment tests as well as long-term results suggest that the epiphyseal cartilage is trophically normalized in patients with early and advanced stages of the disease because of improvement in tissue trophism, higher production of the synovial fluid, and better osmosis and diffusion. It results in diminished cellular degeneration, abatement or alleviation of clinical symptoms, primarily those of secondary synovitis, and

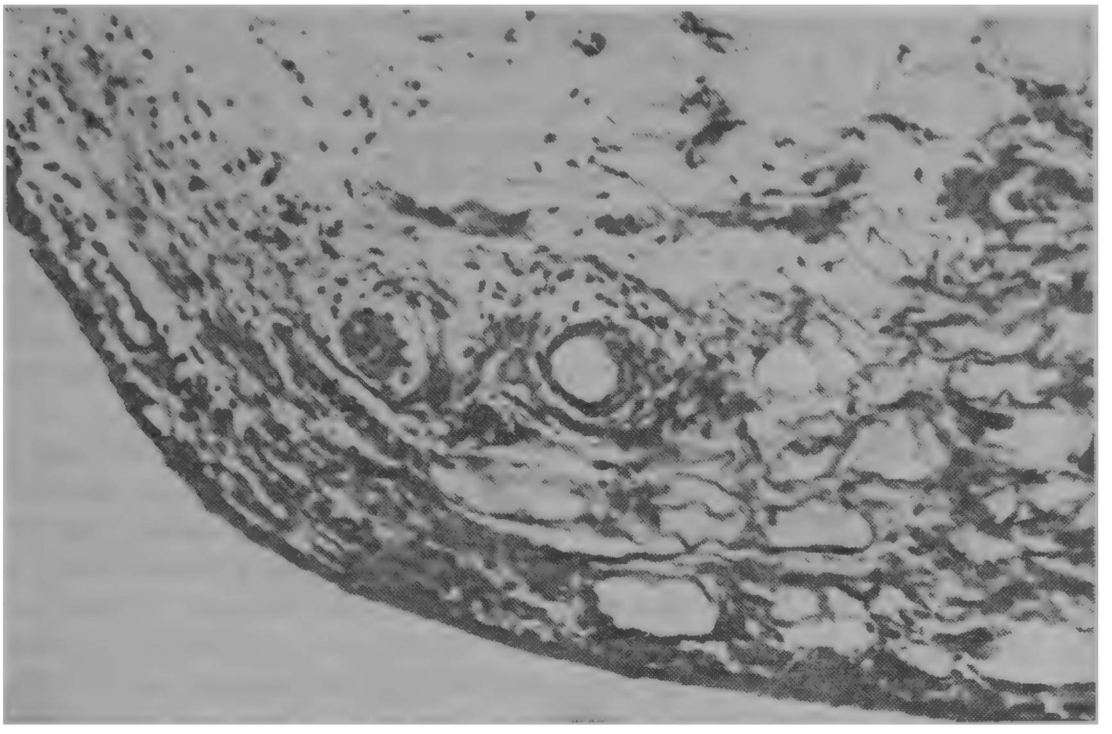

Fig. 13. Synovial membrane in advanced osteoarthrosis deformans.
Reduced number and altered shape of synoviocytes, adipose and fibrillar tissues, degeneration of collagen fibres, reduced number of blood vessels; × 125.

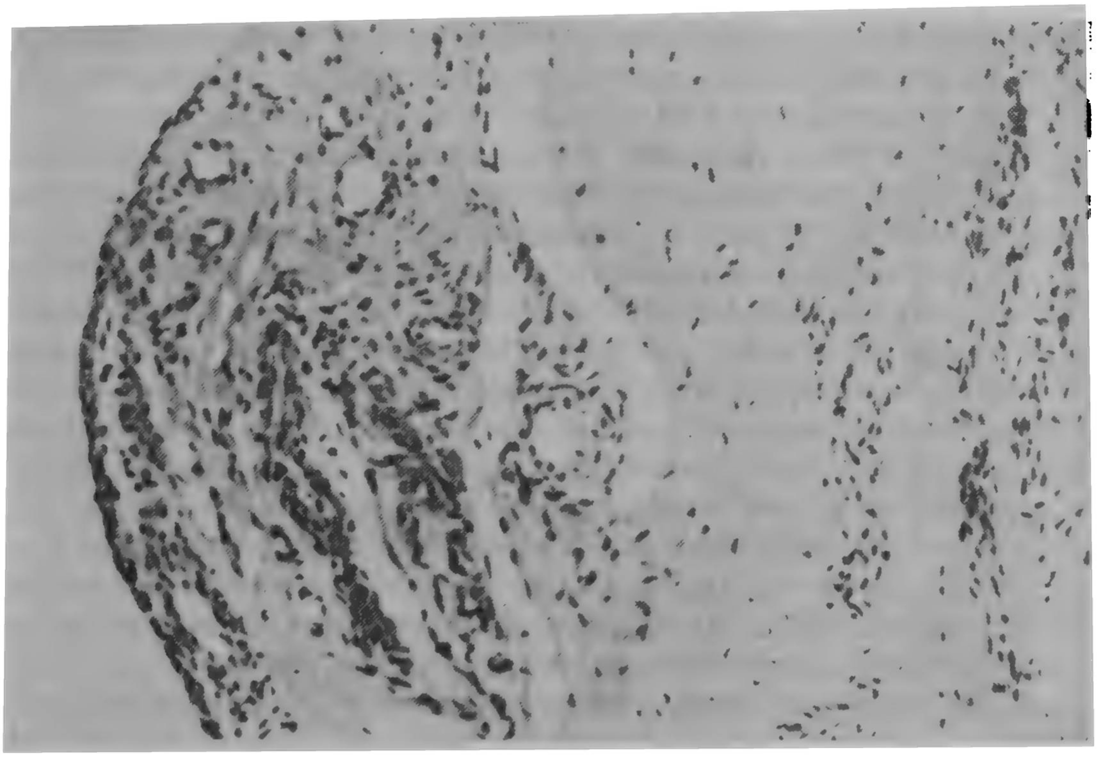

Fig. 14. Advanced osteoarthrosis deformans.
Greater number of small vessels in the synovia in 9 months following treatment with sulphide baths; lipomatosis reduced and cell numbers increased; × 125.

locomotor improvement. Therapy was less effective in the chronic, torpid course of the disease.

It should be emphasized that the sulphide baths have a good effect on the morphology of the synovia and epiphyseal cartilage: cellular reactions are activated in the synovial membrane, and its vascularization is increased, with parietal cells and synovial villi appearing on the membrane surface within 6-8 months. These changes, together with trophic improvement of skeletal muscles, bursae and ligaments, visceral organs, mainly the myocardium and digestive tract, constitute the basis of clinical improvement and better locomotor function.

Clinical observations of patients receiving therapeutic complexes consisting of radon baths (40 and 120 nanocurie/l), exercises and massage have shown that better general condition and reduced joint pain during exercise and at rest were exhibited by 45 per cent of all patients after 5-7 radon baths and 5-7 exercise/massage procedures. Muscular, especially leg, fatigue was much less, walking upstairs easier, appetite and sleep better; irritability was lower, and unpleasant sensations in the cardiac area were absent. However, joint pain, general condition and sleep became worse, and a muscular 'gnawing' sensation and calf heaviness appeared by 5-7 baths in 16.3 per cent of all patients. In some patients there were an increase in ESR and C-reactive protein levels, and slight leukocytosis. These symptoms indicate a balneopathologic response. Subsequent application of radon baths of the same concentration resulted in the disappearance of these complications. Major clinical symptoms subsided by the end of the course of treatment (14-16 baths).

All patients who received radon baths with concentrations of 200 nanocurie/l and especially 400 nanocurie/l showed worsening of general condition, weakness, undue fatigue, retrosternal pain, headaches, joint pain and oedema, sleep disorders and higher irritability by 5-7 procedures. Adverse effects of radon baths with concentrations of 400 nanocurie/l were particularly pronounced in patients with hypertension or hypotension, ischaemic heart disease, various clinical symptoms of neurosis, and intercurrent locomotor and digestive diseases. Further use of radon baths of this concentration resulted in symptoms of acute secondary synovitis and aggravation of the degenerative process both in the joints and visceral organs. Symptoms of diskogenic radiculitis, and posterior cervical sympathetic syndrome with cerebral disorders were aggravated. Biochemical tests also indicated an intensification activity of the disease.

Combined therapy using radon baths with concentrations of 40 and 120 nanocurie/l relieved pain in patients with advanced osteoarthrosis deformans. At the end of therapy, pain was absent during exercises in one-third of all patients and was less severe in more than half of all patients. Joint crepitation was reduced in the majority

of patients. The movement range was increased in half of the patients, with an improvement in flexion, extension, abduction, adduction, and rotation. Secondary synovitis was alleviated by radon baths with concentrations of 40 and 120 nanocurie/l in 14 per cent of patients with advanced osteoarthrosis deformans; joint pain was lessened, especially on palpation, and while walking up or down the stairs, no joint swelling was seen, and ESR, serum C-reactive protein and sialic acid levels returned to normal. Osteophytes and subchondral sclerosis showed little change on X-ray.

All clinical symptoms were aggravated by the baths with radon concentration of 400 nanocurie/l in patients with advanced disease, indicating deterioration of the disease (Gerasimenko, 1978).

In 50 per cent of patients with chronic deforming osteoarthrosis and persistent degenerative disorders, baths with radon concentrations of 40 and 120 nanocurie/l reduced pain at rest; however, it increased with long walking. The mentioned therapy increased the articular movement range in less than half of all patients. Claudication was lessened by the therapy in 20 per cent of patients of this group. In addition, knee-joint crepitation was reduced in all patients with chronic disease.

Nevertheless, clinical and X-ray bone and cartilage abnormalities were not very responsive to combined therapy. Probably, the improvement in the extremity circulation, muscular and skeletal trophism, steroid metabolism and ion balance all lead to intensified metabolism in the synovial membrane, trophic improvement in the joint, and strengthening of muscles, but clinical symptoms at this stage are so prominent that positive response may be elusive. Subjectively, greater strength and muscular contraction are reported by patients.

It must be mentioned that patients (35 per cent) receiving baths with 120 and 200 nanocurie/l concentrations of radon reported greater pain relief than those receiving baths with a 40 nanocurie/l radon concentration. Apart from favourable effect of low-concentration radon baths on the clinical course of osteoarthrosis deformans and vegetative vascular processes (distal extremities became warmer, pulsation of the dorsal foot artery and fibular artery improved, sweating became normal, muscular tone and skin turgor increased), there was a biochemical improvement. Catecholamine levels in 24-hour urine and proteoglycan-like compound and lysosomal enzyme levels in blood serum suggested the beneficial effect of this therapy. Catecholamine levels varied in patients who received different therapeutic complexes including radon baths with concentrations of 40, 120, 200 and 400 nanocurie/l.

In order to evaluate trophic changes on the cellular and subcellular levels induced by the baths with radon concentrations of 40 and 120 nanocurie/l, acid hydrolase activity and proteoglycan-like compound levels were examined (Tables 4 and 5).

Table 4. Alteration of Serum and Leukocyte Acid Hydrolases in Patients with Osteoarthrosis Deformans Treated with Radon Baths of 40 to 120 Nanocurie/l Concentrations (after Arypaeva)

Disease stage	Number of bath-treated patients		Serum acid phosphatase		Leukocyte acid hydrolase		Serum acid hydrolase	
	40 nCi/l	120 nCi/l	40 nCi/l	120 nCi/l	40 nCi/l	120 nCi/l	40 nCi/l	120 nCi/l
Early	16	28	6.6±0.6 $P_1 < 0.01$ $P_2 < 0.001$	7.8±0.3 $P_1 < 0.001$ $P_2 < 0.002$	3.1±0.2 $P_1 < 0.05$ $P_2 < 0.001$	2.7±0.1 $P_1 < 0.05$ $P_2 < 0.05$	0.80±0.05 $P_1 < 0.05$ $P_2 < 0.05$	0.9±0.02 $P_1 < 0.01$ $P_2 < 0.02$
Advanced	18	25	7.5±0.6 $P_1 < 0.001$ $P_2 < 0.05$	8.1±0.3 $P_1 < 0.001$ $P_2 < 0.05$	3.2±0.1 $P_1 < 0.05$ $P_2 < 0.001$	2.7±0.07 $P_1 < 0.05$ $P_2 < 0.001$	0.92±0.02 $P_1 < 0.01$ $P_2 < 0.05$	0.99±0.03 $P_1 < 0.001$ $P_2 < 0.05$
Chronic	20	20	10.1±0.4 $P_1 < 0.001$ $P_2 < 0.001$	10.9±0.6 $P_1 < 0.001$ $P_2 < 0.05$	2.8±0.1 $P_1 < 0.05$ $P_2 < 0.002$	2.7±0.1 $P_1 < 0.05$ $P_2 < 0.001$	1.0±0.03 $P_1 < 0.001$ $P_2 < 0.001$	1.08±0.05 $P_1 < 0.001$ $P_2 < 0.01$
Total	54	73	7.8±0.3 $P_1 < 0.001$ $P_2 < 0.001$	8.2±0.3 $P_1 < 0.001$ $P_2 < 0.001$	3.0±0.1 $P_1 < 0.05$ $P_2 < 0.002$	2.7±0.06 $P_1 < 0.05$ $P_2 < 0.02$	0.9±0.02 $P_1 < 0.01$ $P_2 < 0.001$	0.97±0.02 $P_1 < 0.001$ $P_2 < 0.001$
Normal subjects ($n = 24$)			4.4±0.3		2.7±0.03		0.76±0.05	

Note: P_1 was calculated in relation to normal values; P_2 in relation to pretreatment findings.

The data presented indicate that a radon concentration of 40 nanocurie/l was most effective in reducing serum acid phosphatase levels in all stages of the disease; leukocyte acid hydrolase levels were more commonly reduced (approached normal values) by a concentration of 120 nanocurie/l. Perhaps this was due to the direct effect of α-rays on the cell membrane. It causes consolidation and stabilization of the cell membrane, and a reduction in intercellular release of enzymes and their activity which indicates cell destruction: acid hydrolase activity is reduced in torpid degeneration of the connective tissue, synovial cellular structures, and chondrocytes.

Moreover, blood supply to synovial cells, tone and reactivity of the sympathetic nervous system, and secretion of synovial fluid are improved by the mentioned radon concentrations, resulting in better trophism of the cartilage and its higher resistance to mechanical loads. Because of these changes and lower activity of lysosomal enzymes, cartilage destruction and release of proteoglycan-like compounds are less, and this accounts for the clinically observed parallelism between the alleviation of clinical manifestations and the reduction of levels of these compounds, both total values and fractions 1 and 2. It is more marked in patients suffering from early and advanced stages of the disease.

The levels and activity of lysosomal enzymes are enhanced by radon baths with concentrations of 200 and 400 nanocurie/l. The levels of proteoglycan-like compounds in blood serum are also raised. Simultaneously observed local and systemic haemodynamic disorders and clinical worsening suggest that radon baths of these concentrations are contraindicated in the mentioned forms of the disease.

Therefore, the analysis of activity of lysosomal enzymes, metabolism of catecholamines and their accumulation in patients with osteoarthrosis deformans receiving radon baths has shown that intricate changes occur in various systems of the body by the end of therapy. These changes are due to neuroreflex processes whose primary mechanisms are formed in neural receptors of the skin and in the internal medium of the body: some portion of α-rays of the radon baths has a direct influence on exteroceptors and cellular structures of the skin and upper respiratory mucosa, while another, smaller portion, arrives in the humoral medium, exerting direct effect on vascular interoceptors, subcortical structures, and cells of the synovial membrane. Subsequent changes occur on different levels of the nervous system, increasingly involving other functional systems of the body. These processes have been formulated by Tsarfis in the theory of cascade effects of resort and physical therapeutic factors on patients*.

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* *Proceedings of the 20th Annual Scientific Session of the Institute of Physiotherapy and Spa Treatment*, March 11-12, 1971, 22, Moscow, 1972, 70-87.

Table 5. Alteration of Proteoglycan-Like Compound Levels in Serum of Patients

Disease stage	Number of patients treated with		Proteoglycan-like compo				
			Total			Fraction	
			Norm = 13.5±1.0			Norm =	
	40 nCi/l	120 nCi/l	Before treatment	After treatment with 40 nCi/l	After treatment with 120 nCi/l	Before treatment	After treatment with 40 nCi/l
Early	16	28	19.7±0.9 $P_1 < 0.001$	14.2±0.8 $P_1 < 0.05$ $P_2 < 0.02$	16.5±1.1 $P_1 < 0.005$ $P_2 < 0.002$	10.4±0.5 $P_1 < 0.001$	5.6±0.9 $P_1 < 0.05$ $P_2 < 0.02$
Advanced	18	25	24.2±0.9 $P_1 < 0.001$	18.6±0.8 $P_1 < 0.002$ $P_2 < 0.02$	18.5±1.1 $P_1 < 0.001$ $P_2 < 0.002$	11.9±0.8 $P_1 < 0.001$	7.8±0.7 $P_1 < 0.02$ $P_2 < 0.001$
Chronic	20	20	34.5±0.8 $P_1 < 0.001$	23.2±0.7 $P_1 < 0.001$ $P_2 < 0.001$	32.3±1.0 $P_1 < 0.001$ $P_2 < 0.05$	18.4±0.5 $P_1 < 0.001$	2.3±0.8 $P_1 < 0.001$ $P_2 < 0.001$
Total	54	73	22.8±1.0 $P_1 < 0.001$	18.5±0.6 $P_1 < 0.001$ $P_2 < 0.001$	19.9±0.6 $P_1 < 0.001$ $P_2 < 0.02$	10.0±0.4 $P_1 < 0.001$	9.7±0.3 $P_1 < 0.01$ $P_2 < 0.001$

Note: P_1 was calculated in relation to normal values; P_2 in relation to pretreatment

Morphological and histoenzymochemical changes in the synovia and epiphyseal cartilage, which occur in different stages of the disease, have important implications for understanding the processes induced by the radon baths in patients with osteoarthrosis deformans. Thirty-eight of 44 puncture biopsy specimens of the synovial membrane of patients with early stage of the disease showed morphological signs which, compared with pretreatment findings, led Tsarfis and Arutyunov to conclude that radon therapy caused pronounced structural and histoenzymochemical alterations in the synovia and cartilage (Tables 6 and 7). Proliferative activity of cells and cellular metabolism were intensified. After therapy, synoviocytes were detected on greater surfaces of the synovial membrane, and tended to constitute a greater proportion (to 7.6 ± 0.25 per cent) in other cells. Most synoviocytes were enlarged, cube-shaped, and had a mildly pyroninophilic cytoplasm showing a moderate PAS test and marked activity of oxidative enzymes. The synovial layer of these sites grew 0.49 μmol thicker after a concentration of 40 nanocurie/l, and 0.63 μmol thicker after a concentration of 120 nanocurie/l

h Deforming Osteoarthrosis Treated with 40 nCi/l and 120 nCi/l Radon Baths

s in serum (mg %)

	Fraction 2			Fraction 3		
±0.5	Norm = 6.8±0.6			Norm = 3.4±0.3		
After eatment with 20 nCi/l	Before treatment	After treatment with 40 nCi/l	After treatment with 120 nCi/l	Before treatment	After treatment with 40 nCi/l	After treatment with 120 nCi/l
.6±0.8 $_1 < 0.05$ $_2 < 0.001$	7.1±0.4 $P_1 < 0.05$	6.2±0.5 $P_1 < 0.05$ $P_2 < 0.05$	5.9±0.5 $P_1 < 0.05$ $P_2 < 0.05$	2.2±0.2 $P_1 < 0.01$	2.4±0.2 $P_1 < 0.01$ $P_2 < 0.001$	2.0±0.3 $P_1 < 0.01$ $P_2 < 0.05$
.3±1.0 $_1 < 0.002$ $_2 < 0.002$	8.9±1.0 $P_1 < 0.05$	7.8±0.5 $P_1 < 0.05$ $P_2 < 0.002$	7.5±0.4 $P_1 < 0.05$ $P_2 < 0.002$	3.4±0.4 $P_1 < 0.05$	3.0±0.1 $P_1 < 0.05$ $P_2 < 0.05$	2.7±0.3 $P_1 < 0.05$ $P_2 < 0.05$
.3±0.7 $_1 < 0.001$ $_2 < 0.002$	12.5±0.9 $P_1 < 0.001$	7.9±0.01 $P_1 < 0.001$ $P_2 < 0.001$	12.5±0.8 $P_1 < 0.001$ $P_2 < 0.001$	3.6±0.8 $P_1 < 0.05$	3.0±0.2 $P_1 < 0.05$ $P_2 < 0.001$	3.5±0.2 $P_1 < 0.05$ $P_2 < 0.05$
.7±0.5 $_1 < 0.001$ $_2 < 0.002$	9.7±0.5 $P_1 < 0.002$	6.0±0.2 $P_1 < 0.02$ $P_2 < 0.001$	9.3±0.2 $P_1 < 0.002$ $P_2 < 0.05$	3.1±0.1 $P_1 \pm 0.05$	2.8±0.1 $P_1 < 0.05$ $P_2 < 0.001$	2.9±0.1 $P_1 < 0.05$ $P_2 < 0.002$

lings.

was used. No significant differences could be detected in morphological alterations in the mentioned groups of patients. Cytophotometry showed certain changes in lactate dehydrogenase and acid phosphatase activity. On about half of the synovial surface, the synoviocytes were arranged in 3-5 layers, a portion of them cube-shaped or, occasionally, cylindrical (Table 8). The cell cytoplasm was pyroninophilic and PAS-positive. The synoviocytes contained small granules, and were metachromatic when stained with toluidine blue. A high activity of glycolytic enzymes, Krebs cycle, and acid phosphatase was found in some synovial cells, and a moderate activity of glucose-6-phosphate dehydrogenase in others. Heterogeneity of the enzyme activities of the 'dark' and 'light' cells was not influenced by therapy. However, the activities of lactate dehydrogenase and acid phosphatase were increased by the baths. Cytophotometry showed oedema and local γ-metachromasia in the interstitial tissue of the synovial subintimal layer (when stained with toluidine blue). Membrane capillaries showed elevated alkaline phosphatase activity, the interstitial substance of the subintimal layer was loos-

Table 6. Alteration of the Synovial Layer Thickness (μm) in Osteoarthrosis

Synovial layer thickness	Normal synovial membrane	Stage of		
		Early		
		Before treatment	Immediately after treatment	In 8 months
At atrophic sites	11.36±0.56	5.06±0.3 $P_1 < 0.05$	5.55±0.27 $P_1 < 0.05$ $P_2 < 0.05$	5.46±0.44 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$
At proliferative sites	11.36±0.56	11.06±0.44 $P_1 < 0.05$	11.31±0.36 $P_1 < 0.05$ $P_2 < 0.05$	12.7±0.37 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$

Note: P_1 was calculated in relation to normal values; P_2 in relation to pre- and P_4 relative values obtained before the treatment and 8 months; P_5 relative values obta between the advanced and chronic stages of the disease.

ened, and collagen fibres were distinctly outlined. They had significant numbers of histiocytes and macrophages, with the cytoplasm positive to acid phosphatase. Acid phosphatase was also seen in fibroblasts. Perivascular small lymphoid and macrophage infiltrates showing solitary mast cells were detected in the synovia of some patients (Tables 9, 10).

Table 7. Alteration of the Thickness of the Synovial Layer (μm) in

Synovial layer thickness	Normal synovial membrane	Stage of		
		Early		
		Before treatment	Immediately after treatment	In 8 months
At atrophic sites	11.36±0.56	5.06±0.23 $P_1 < 0.05$	5.69±0.23 $P_1 < 0.01$ $P_2 < 0.05$	5.36±0.29 $P_1 < 0.01$ $P_3 < 0.05$ $P_4 < 0.05$
At proliferative sites	11.36±0.56	11.06±0.44 $P_1 < 0.05$ $P_2 < 0.05$	12.06±0.32 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$	12.51±0.41 $P_1 < 0.05$ $P_5 < 0.05$

Note: The data were statistically evaluated as in Table 6.

Deformans Treated with 40 nCi/l Radon Baths

disease

Advanced			Chronic		
Before treatment	Immediately after treatment	In 8 months	Before treatment	Immediately after treatment	In 8 months
2.85±0.17 $P_1 < 0.01$ $P_5 < 0.05$	2.98±0.18 $P_1 < 0.01$ $P_2 < 0.05$	2.83±0.3 $P_1 < 0.01$ $P_3 < 0.05$ $P_4 < 0.05$	1.35±0.21 $P_1 < 0.001$ $P_6 < 0.05$	1.36±0.15 $P_1 < 0.001$ $P_2 < 0.05$	1.89±0.26 $P_1 < 0.001$ $P_2 < 0.05$ $P_3 < 0.05$
8.76±0.29 $P_1 < 0.05$ $P_5 < 0.05$	9.64±0.29 $P_1 < 0.05$ $P_2 < 0.05$	10.68±0.53 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$	—	—	—

posttreatment values; P_3 relative values obtained after the treatment and in 8 months; ined between the early and advanced stages of the disease; P_6 relative values obtained

Evaluation of volume proportions of the synovial constituents showed that the baths with radon concentrations of 40 and 120 nanocurie/l increased the volume proportion of vessels in the subintimal layer: percentage of capillaries rose by 0.71 arbitrary units as radon concentration was 40 nanocurie/l and decreased by 3.1 per cent as the concentration was elevated to 120 nanocurie/l. Most vessels (arte-

Osteoarthrosis Deformans Treated with 120 nCi/l Radon Baths

disease

Advanced			Chronic		
Before treatment	Immediately after treatment	In 8 months	Before treatment	Immediately after treatment	In 8 months
2.85±0.17 $P_1 < 0.01$ $P_5 < 0.05$	2.72±0.16 $P_1 < 0.01$ $P_2 < 0.05$	3.12±0.27 $P_1 < 0.01$ $P_3 < 0.05$ $P_4 < 0.05$	1.35±0.21 $P_1 < 0.001$ $P_5 < 0.05$	1.3±0.13 $P_1 < 0.001$ $P_5 < 0.05$	1.61±0.19 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$
8.76±0.29 $P_1 < 0.05$ $P_2 < 0.05$	8.88±0.25 $P_1 < 0.01$ $P_2 < 0.05$	9.77±0.42 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$	—	—	—

Table 8. Results of Cytophotometric Examination of Synoviocytes (Arbit
120 nCi/l Radon Baths

Synoviocytes	Normal synovial membrane	Stage of		
		Early		
		'Light' cells at atrophic sites		
		Before treatment	Immediately after treatment	In 8 months
Lactate dehydrogenase	'Dark' cells 73.53±0.13	15.98±0.31 $P_1 < 0.001$	16.44±0.19 $P_1 < 0.05$	17.01±0.25 $P_1 < 0.05$
	'Light' cells 17.18±0.19		$P_2 < 0.05$	$P_3 < 0.05$ $P_4 < 0.05$
Acid phosphatase	'Dark cells' 72.63±0.26	14.07±0.19 $P_1 < 0.001$	14.99±0.34 $P_1 < 0.05$	15.41±0.23 $P_1 < 0.05$
	'Light' cells 16.47±0.19		$P_2 < 0.05$	$P_3 < 0.05$ $P_4 < 0.05$

Synoviocytes	Normal synovial membrane	Stage of		
		Chro		
		Before treatment	Immediately after treatment	In 8 months
—	—	55.42±0.18 $P_1 < 0.001$	57.49±0.23 $P_1 < 0.001$	58.31±0.34 $P_1 < 0.001$
		$P_5 < 0.01$	$P_2 < 0.05$	$P_3 < 0.05$ $P_4 < 0.05$
—	—	58.07±0.29 $P_1 < 0.001$	59.16±0.34 $P_1 < 0.001$	62.01±0.18 $P_1 < 0.001$
		$P_5 < 0.01$	$P_2 < 0.05$	$P_2 < 0.01$ $P_3 < 0.01$

Note: The data were statistically evaluated as stated in Table 6.

rioles, small arteries) had thickened walls. Capillaries, venules and, seldom, arterioles had succulent endothelium and loosened walls.

The proportion of sclerosed sites in the synovial membrane was reduced by 3.2 per cent by a radon concentration of 40 nanocurie/l; it was reduced to 18.54 ± 0.41 by baths of greater concentrations

rary Units) in Osteoarthrosis Deformans before and after Treatment with

disease					
Advanced					
'Dark' cells at proliferative sites			'Light' cells at atrophic sites		
Before treatment	Immediately after treatment	In 8 months	Before treatment	Immediately after treatment	In 8 months
69.21 ± 0.21 $P_1 < 0.05$	71.32 ± 0.19 $P_1 < 0.01$ $P_2 < 0.05$	72.0 ± 0.38 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$	10.94 ± 0.26 $P_1 < 0.001$ $P_5 < 0.01$	11.73 ± 0.21 $P_1 < 0.001$ $P_2 < 0.05$	11.98 ± 0.35 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$
68.94 ± 0.24 $P_1 < 0.001$	69.18 ± 0.24 $P_1 < 0.001$ $P_2 < 0.05$	70.34 ± 0.19 $P_1 \leqslant 0.05$ $P_3 < 0.05$ $P_4 < 0.01$	12.98 ± 0.42 $P_1 < 0.01$ $P_5 < 0.01$	13.43 ± 0.51 $P_1 < 0.01$ $P_2 < 0.05$	13.89 ± 0.23 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$

disease					
nic					
Before treatment	Immediately after treatment	In 8 months	Before treatment	Immediately after treatment	In 8 months
—	—	—	8.97 ± 0.3 $P_1 < 0.001$ $P_6 < 0.001$	9.34 ± 0.19 $P_1 < 0.001$ $P_2 < 0.05$	9.83 ± 0.32 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$
			10.74 ± 0.51 $P_1 < 0.001$ $P_6 < 0.001$	11.73 ± 0.34 $P_1 < 0.001$ $P_2 < 0.05$	12.34 ± 0.27 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$

(120 nanocurie/l). A similar synovial response was noted in terms of hyalinosis: baths with a radon concentration of 40 nanocurie/l reduced hyalinosis by 0.68 per cent, whereas a concentration of 120 nanocurie/l reduced it by 0.78 per cent. Local proliferation of histiocytes having large bean-like nuclei and a laminar, slightly pyronin-

Table 9. Volume Ratios of Structural Changes in the Synovial Membranes Radon Baths

Characteristics of structural elements in the synovial membrane	Normal synovial membrane	Stage of		
		Early		
		Before treatment	Immediately after treatment	In 8 months
Synoviocytes	10.24±0.45	6.68±0.37 $P_1<0.001$	7.64±0.25 $P_1<0.001$ $P_2<0.05$	8.22±0.39 $P_1<0.001$ $P_3<0.05$ $P_4<0.05$
Number of cells in the subintimal layer	4.51±0.31	4.03±0.34 $P_1<0.05$	4.46±0.3 $P_1<0.5$ $P_2<0.05$	4.49±0.49 $P_1<0.5$ $P_3<0.05$ $P_4<0.05$
Vessels	8.6±0.42	6.34±0.43 $P_1<0.001$	7.07±0.41 $P_1<0.01$ $P_1<0.05$	8.16±0.62 $P_1<0.05$ $P_3<0.05$ $P_4<0.05$
Sclerosis	15.13±0.54	20.4±0.71 $P_1<0.001$	17.23±0.5 $P_1<0.001$ $P_2<0.001$	16.09±0.73 $P_1<0.01$ $P_3<0.05$ $P_4<0.001$
Hyalinosis	6.67±0.37	6.18±0.19 $P_1<0.05$	6.25±0.19 $P_1<0.05$ $P_2<0.05$	6.27±0.23 $P_1<0.05$ $P_3<0.05$ $P_4<0.05$
Lipomatosis	6.67±0.37	6.18±0.19 $P_1<0.05$	6.25±0.19 $P_1<0.05$ $P_2<0.05$	6.27±0.23 $P_1<0.05$ $P_3<0.05$ $P_4<0.05$

Note: The data were statistically evaluated as in Table 6.

ophilic cytoplasm was seen in the synoviocyte-adjacent subintimal layer. There was no significant change in the proportion of lipomatous sites, however.

These findings show that the baths with a radon concentration of 40 nanocurie/l caused synoviocyte proliferation and diminution of

(%) in Osteoarthrosis Deformans before and after Treatment with 40 nCi/l

disease					
Advanced			Chronic		
Before treatment	Immediately after treatment	In 8 months	Before treatment	Immediately after treatment	In 8 months
3.88 ± 0.26 $P_1 < 0.001$ $P_5 < 0.05$	4.46 ± 0.2 $P_1 < 0.001$ $P_2 < 0.05$ $P_5 < 0.01$	5.93 ± 0.35 $P_1 < 0.001$ $P_3 < 0.01$ $P_4 < 0.001$ $P_5 < 0.05$	1.86 ± 0.1 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.01$	1.32 ± 0.16 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.001$ $P_7 < 0.001$	1.91 ± 0.22 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.01$ $P_7 < 0.001$
2.07 ± 0.19 $P_1 < 0.001$ $P_5 < 0.05$	3.55 ± 0.22 $P_1 < 0.01$ $P_3 < 0.01$ $P_5 < 0.05$	4.26 ± 0.49 $P_1 < 0.05$ $P_3 < 0.01$ $P_4 < 0.01$ $P_5 < 0.05$	1.93 ± 0.17 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.05$	2.08 ± 0.02 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.01$ $P_7 < 0.01$	2.63 ± 0.14 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.05$ $P_7 < 0.05$
4.18 ± 0.33 $P_1 < 0.001$ $P_5 < 0.05$	5.21 ± 0.29 $P_1 < 0.001$ $P_2 < 0.001$ $P_5 < 0.05$	7.66 ± 0.59 $P_1 < 0.01$ $P_3 < 0.001$ $P_4 < 0.001$	2.26 ± 0.31 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.01$	2.18 ± 0.2 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.01$ $P_7 < 0.001$	2.81 ± 0.24 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.01$ $P_7 < 0.01$
23.77 ± 0.56 $P_1 < 0.001$ $P_5 < 0.05$	21.98 ± 0.47 $P_1 < 0.001$ $P_2 < 0.05$ $P_5 < 0.01$	20.46 ± 0.77 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.001$ $P_5 < 0.001$	25.78 ± 0.44 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.05$	25.98 ± 0.33 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.01$ $P_7 < 0.001$	22.69 ± 0.3 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.05$ $P_7 < 0.01$
5.52 ± 0.25 $P_1 < 0.05$ $P_5 < 0.05$	5.36 ± 0.17 $P_1 < 0.05$ $P_2 < 0.05$ $P_5 < 0.05$	5.43 ± 0.28 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$ $P_5 < 0.05$	8.49 ± 0.37 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.05$	8.3 ± 0.5 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.05$ $P_7 < 0.05$	8.15 ± 0.41 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.05$
5.52 ± 0.25 $P_1 < 0.05$ $P_5 < 0.05$	5.36 ± 0.17 $P_1 < 0.05$ $P_2 < 0.05$ $P_5 < 0.05$	5.43 ± 0.28 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_5 < 0.005$	8.49 ± 0.37 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.05$	8.3 ± 0.5 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.05$ $P_7 < 0.05$	8.15 ± 0.41 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.05$ $P_7 < 0.05$

sclerosed sites more markedly than baths with a radon concentration of 120 nanocurie/l.

Of paramount interest were the morphological and metabolic modifications of the epiphyseal cartilage by radon baths of the mentioned concentrations. Pretreatment morphological findings of the epiph-

Table 10. Volume Ratios of Structural Changes in the Synovial Membranes Radon Baths

Characteristics of structural elements in the synovial membrane	Normal synovial membrane	Stages of		
		Early		
		Before treatment	Immediately after treatment	In 8 months
Synoviocytes	10.24 ± 0.45	6.68 ± 0.37 $P_1 < 0.001$	6.98 ± 0.24 $P_1 < 0.001$ $P_2 < 0.05$	7.06 ± 0.31 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$
Number of cells in the subintimal layer	4.51 ± 0.31	4.03 ± 0.34 $P_1 < 0.05$	4.23 ± 0.24 $P_1 < 0.05$ $P_2 < 0.05$	4.57 ± 0.37 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$
Vessels	8.6 ± 0.42	6.34 ± 0.43 $P_1 < 0.001$	6.79 ± 0.24 $P_1 < 0.01$ $P_2 < 0.05$	8.02 ± 0.48 $P_1 < 0.05$ $P_3 < 0.01$ $P_4 < 0.001$
Sclerosis	15.13 ± 0.54	20.4 ± 0.71 $P_1 < 0.001$	18.54 ± 0.41 $P_1 < 0.001$ $P_2 < 0.05$	16.47 ± 0.6 $P_1 < 0.01$ $P_3 < 0.01$ $P_4 < 0.001$
Hyalinosis	1.29 ± 0.17	3.91 ± 0.29 $P_1 < 0.001$	3.13 ± 0.16 $P_1 < 0.01$ $P_2 < 0.05$	3.19 ± 0.32 $P_1 < 0.01$ $P_3 < 0.05$ $P_4 < 0.05$
Lipomatosis	6.67 ± 0.37	6.18 ± 0.19 $P_1 < 0.05$	6.41 ± 0.13 $P_1 < 0.05$ $P_2 < 0.05$	6.22 ± 0.15 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$

Note: The data were statistically evaluated as stated in Table 6.

(%) in Osteoarthrosis Deformans before and after Treatment with 120 nCi/l

disease					
Advanced			**Chronic**		
Before treatment	**Immediately** after treatment	In 8 months	**Before** treatment	**Immediately** after treatment	In 8 months
3.88±0.26 $P_1 < 0.001$ $P_5 < 0.05$	4.51±0.2 $P_1 < 0.001$ $P_2 < 0.05$ $P_5 < 0.01$	5.88±0.32 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.01$ $P_5 < 0.05$	1.86±0.17 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.01$	1.94±0.13 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.01$ $P_7 < 0.001$	2.06±0.27 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.01$ $P_7 < 0.001$
2.07±0.19 $P_1 < 0.001$ $P_5 < 0.05$	3.55±0.16 $P_1 < 0.01$ $P_2 < 0.05$ $P_5 < 0.05$	4.33±0.4 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.001$ $P_5 < 0.05$	1.93±0.17 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.05$	1.99±0.06 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.05$ $P_7 < 0.01$	2.34±0.16 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.05$ $P_7 < 0.05$
4.18±0.33 $P_1 < 0.001$ $P_5 < 0.05$	6.05±0.25 $P_1 < 0.01$ $P_2 < 0.01$ $P_5 < 0.05$	7.21±0.54 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.001$ $P_5 < 0.05$	2.26±0.31 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.01$	2.98±0.2 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.01$ $P_7 < 0.001$	3.09±0.38 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.05$ $P_7 < 0.01$
23.77±0.43 $P_1 < 0.001$ $P_2 < 0.01$	20.7±0.43 $P_1 < 0.001$ $P_2 < 0.01$ $P_5 < 0.05$	18.75±0.68 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.001$ $P_5 < 0.01$	25.78±0.44 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.05$	24.91±0.53 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.05$ $P_7 < 0.01$	24.03±0.68 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.05$ $P_7 < 0.01$
6.49±0.31 $P_1 < 0.001$ $P_5 < 0.01$	5.03±0.26 $P_1 < 0.001$ $P_2 < 0.05$ $P_5 < 0.01$	4.39±0.02 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.01$ $P_5 < 0.05$	13.86±0.44 $P_1 < 0.001$ $P_6 < 0.001$ $P_7 < 0.001$	12.83±0.58 $P_1 < 0.001$ $P_2 < 0.05$ $P_6 < 0.001$ $P_7 < 0.001$	12.33±0.55 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.001$ $P_7 < 0.001$
5.52±0.25 $P_1 < 0.05$ $P_5 < 0.05$	5.51±0.22 $P_1 < 0.05$ $P_2 < 0.05$ $P_5 < 0.05$	5.25±0.26 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$ $P_5 < 0.05$	8.49±0.37 $P_1 < 0.001$ $P_6 < 0.05$ $P_7 < 0.05$	8.01±0.32 $P_1 < 0.01$ $P_2 < 0.05$ $P_6 < 0.001$ $P_7 < 0.05$	7.69±0.47 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$ $P_6 < 0.05$ $P_7 < 0.05$

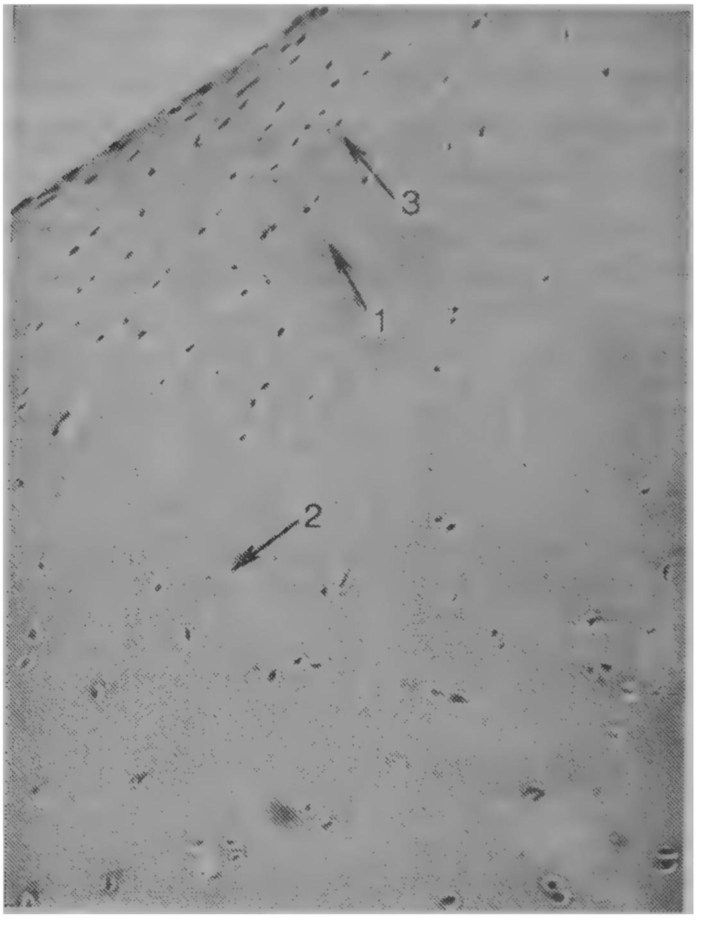


Fig. 15. Early stage of osteoarthrosis deformans. Trophic response of the epiphyseal cartilage to radon baths (120 nCi/l):

1—**recovery of the segmental structure;** ***2***—**smaller numbers of cells as compared with pretreatment ones;** ***3***—**pyknosis of nuclei of superficial chondrocytes. Haematoxylin and eosin; × 200**

yseal cartilage were compared with those recorded after therapy. Chondrocyte proliferation was made greater and the basic substance of the matrix more prominent by the radon baths. Small, prolonged and irregularly located in the cell substance before therapy, chondrocytes became normally shaped after therapy. Toluidine blue staining of the proliferative sites revealed mild metachromasia of the basic substance. Metachromasia and PAS test were less intense in the 1st and 2nd segments of the epiphyseal cartilage (Fig. 15).

Patients with early stage of the disease were found to suffer from local cartilage degeneration. Numbers of chondrocytes in the superficial areas were diminished, or they were absent; some of the remaining cells had pyknotic nuclei and foamy cytoplasm. The basic substance of these sites had a highly negative PAS test, and metachromasia was absent upon toluidine blue staining (Fig. 16).

These data show that cellular trophism, primarily that of the 1st and 2nd epiphyseal cartilage segments, is stimulated by the radon baths as blood supply and metabolism are improved in the synovia and lysosomal enzyme activity and metabolite levels are decreased in the synovial fluid and blood serum.

However, trophic recovery may be difficult in progressive forms of the disease, especially in the presence of synovial cell atrophy and

Fig. 16. Structure of the epiphyseal cartilage in a patient with early-stage osteoarthrosis deformans treated with 120 nCi/l radon baths:

1—intact site of the cartilage retaining its segmental structure; *2*—strong reduction in chondrocyte numbers; *3*—nuclear pyknosis in some of intact chondrocytes; *4*—damaged chondrocytes. Haematoxylin and eosin; × 200

lower blood supply of the subsynovial layer, hormone transport, and metabolite excretion, all of which are characteristic of the advanced and chronic stages.

We have evaluated morphological changes produced by radon baths in patients with advanced and chronic osteoarthrosis deformans. In 8 of 41 puncture biopsy specimens of the synovial membranes of patients with advanced osteoarthrosis deformans, sclerotic, atrophic and local proliferative abnormalities were found; their severity was dependent upon the duration of the disease. The sclerotic and atrophic abnormalities were not sharply manifest in five patients with 1.5 to 5-year history of the disease. Cellular proliferative response to radon baths was characterized by a series of features: focal proliferation was observed in synovial cells which had the pyroninophilic cytoplasm with high activities of acid phosphatase and glycolytic enzymes; activation of cellular reaction was found in the subintimal layer (containing significant numbers of histiocytes and macrophages), with lymphocytes and solitary plasma or mast cells seen around the vessels; wall loosening and elevated alkaline phosphatase activity were observed in venules and capillaries, with endothelium swelling in capillary membranes; staining of the interstitial tissue with toluidine blue showed small sites of γ-metachromasia and clearly outlined collagen bundles, and PAS-positive vascular walls. Sclerotic

Table 11. Results of Cytophotometric Examination of Synoviocytes (Arbitra
Radon Baths

Synoviocyte enzymes	Normal synovial membrane		Stage		
			Early		
			'Light' cells at atrophic sites		
	'Dark' cells	'Light' cells	Before treatment	Immediately after treatment	In 8 montl
Lactate dehydrogenase	73.53 ± 0.13	17.18 ± 0.19	15.98 ± 0.31 $P_1 < 0.001$	16.47 ± 0.31 $P_1 < 0.001$ $P_2 < 0.05$	$16.94 \pm 0.$ $P_1 < 0.0$ $P_3 < 0.0$ $P_4 < 0.0$
Acid phosphatase	72.63 ± 0.26	16.47 ± 0.19	14.07 ± 0.19 $P_1 < 0.001$	14.94 ± 0.27 $P_1 < 0.001$ $P_2 < 0.05$	$15.89 \pm 0.$ $P_1 < 0.0$ $P_3 < 0.0$ $P_4 < 0.0$

Note: The data were statistically evaluated as in Table 6.

and atrophic changes were prevalent in patients with six- and ten-year history of osteoarthrosis deformans; proliferation of synoviocytes and subintimal histiocytes had a small focal pattern.

Histometric analysis showed no statistically significant difference ($P < 0.05$) in synoviocyte proportions (4.46 ± 0.2 per cent), in synovial layer thickness at atrophic sites (11.37 ± 0.41 μmol), or in regeneration of other cells (56.64 ± 0.31 μmol). No significant change was found in lactate dehydrogenase and acid phosphatase metabolism, although the activity of the enzymes clearly tended to increase (Table 11). Enzymic profiles of the synovial cells did not contrast greatly with those obtained in patients before therapy.

These findings corresponded to the clinical response: clinicobiochemical indices of activity of the disease were obviously lower as therapy-associated improvement of the synovial trophism was greater.

Like the foregoing studies (in patients with early-stage disease), this study sought to clarify the positive dynamics of morphological indices in the cartilaginous tissue. It was established that the thickness of the joint cartilage was increased relative to the pretreatment thickness by radon baths. The segmental structure of the joint cartilage was observed at sites that were free of fissures and caries. Chondrocytes of the 2nd segment showed a greater proliferation at these sites, and were irregularly located in the stranded matrix. There was no metachromasia in the basic substance, and PAS test

9.21 ± 0.21 $P_1 < 0.05$	71.13 ± 0.27 $P_1 < 0.01$ $P_2 < 0.05$	72.24 ± 0.27 $P_1 < 0.01$ $P_3 < 0.05$ $P_4 < 0.001$	10.94 ± 0.26 $P_1 < 0.001$ $P_2 < 0.05$	11.37 ± 0.41 $P_1 < 0.001$ $P_2 < 0.05$	11.99 ± 0.19 $P_1 < 0.001$ $P_3 < 0.05$ $P_4 < 0.05$
8.94 ± 0.24 $P_1 < 0.001$	70.03 ± 0.31 $P_1 < 0.01$ $P_2 < 0.001$	71.92 ± 0.41 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.01$	12.98 ± 0.42 $P_1 < 0.01$ $P_5 < 0.05$	13.54 ± 0.41 $P_1 < 0.01$ $P_2 < 0.05$	14.41 ± 0.41 $P_1 < 0.05$ $P_3 < 0.05$ $P_4 < 0.05$

showed low-positive. Focal chondrocyte proliferation was also seen, chondrocytes being enclosed in a single capsule. The chondrocyte cytoplasm showed significant pyroninophilia and a high activity of redox enzymes. The adjacent intercellular substance was metachromatic when stained with toluidine blue. These findings suggested that the metabolism in the chondrocytes and matrix is activated much more slowly than that in the synovial tissue, even when radon therapy is used. This is determined by morphological and pathogenetic factors: even under normal conditions, energy and formative supply of epiphyseal cartilage cells is complicated, since the cartilage is devoid of vessels and nerves. Therefore, its metabolism is slower, as compared with that of other articular tissues. The degenerative process in the cartilage is aggravated by its dependence on the status of the synovial membrane and metaepiphyseal portion of the bone. Nevertheless, substantial morphological and functional improvement is manifest by radon baths during the advanced stage of the disease, resulting in higher trophism of the epiphyseal cartilage and slower progression of the disease.

Analysis of morphological alterations induced by the baths with radon concentrations of 40 and 120 nanocurie/l in puncture biopsy specimens of the synovial membrane of patients with chronic osteoarthrosis deformans revealed the following. Prominent sclerosis and hyalinosis associated with depletion of the microcirculatory vessels

and reduction in subintimal cell counts were observed in all 25 specimens. Distinct subchondral sclerosis, multiple osteophytes and induration of the fibrous capsule and joint-surrounding muscles were detected clinically and by X-rays. In addition, there were clinical symptoms of skin and muscle hypotrophy, muscular hypotonia, nail brittleness, hair loss, anhydrosis. No significant difference was seen in proportions of cells and vessels as well as of foci of sclerosis and hyalinosis when compared with pretreatment findings ($P > 0.05$).

Proliferation signs were found at some sites of the synovia: there were small iselets of synoviocytes, occasionally making up to 1-2 layers of cells, increased counts of histiocytes in the subintimal layer, and slight interstitial metachromasia. Furthermore, a moderate activity of oxidation enzymes and acid phosphatase was histoenzymochemically revealed in synoviocytes and subintimal histiocytes. However, analysis of cytophotometric findings showed no statistically significant difference in pre- and posttreatment data; nor was it seen in the data of patients treated with different doses of radon. Morphological findings corresponded to clinical and, particularly, X-ray data, although subjective clinical improvement was reported by patients. The lack of synovial response accompanied the absence of morphological change in the epiphyseal cartilage. Its thickness was grossly diminished, and remained actually unchanged by therapy.

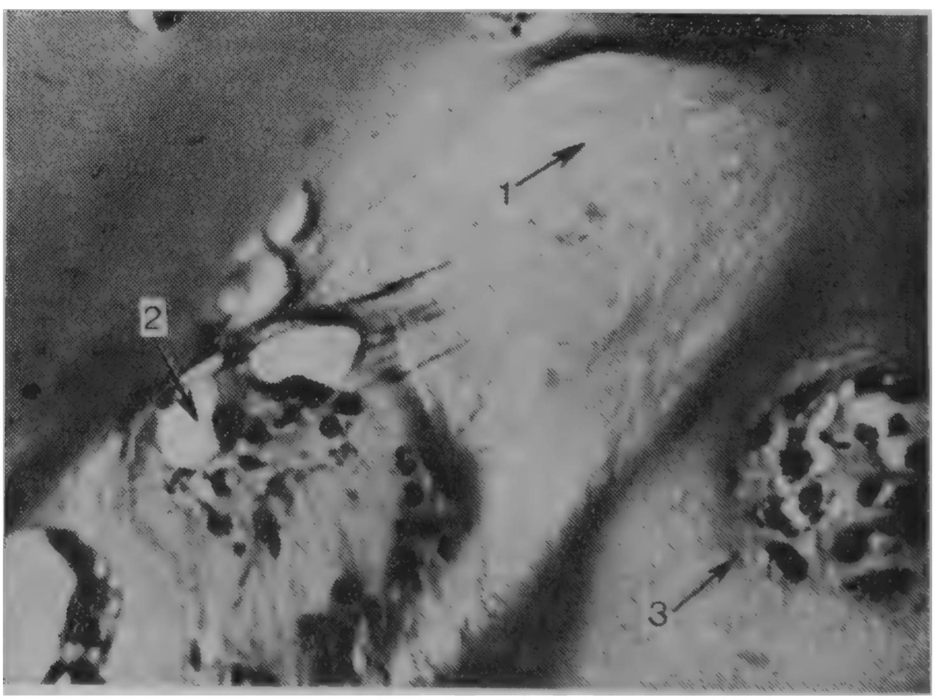


Fig. 17. Severe degenerative abnormalities of the epiphyseal cartilage in chronic osteoarthrosis deformans:

1 prominently fibrillar intercellular substance in the 3rd segment; *2* cyst in the cartilage; *3* local proliferation of chondrocytes with glycoprotein-rich cytoplasm. PAS test. ×270

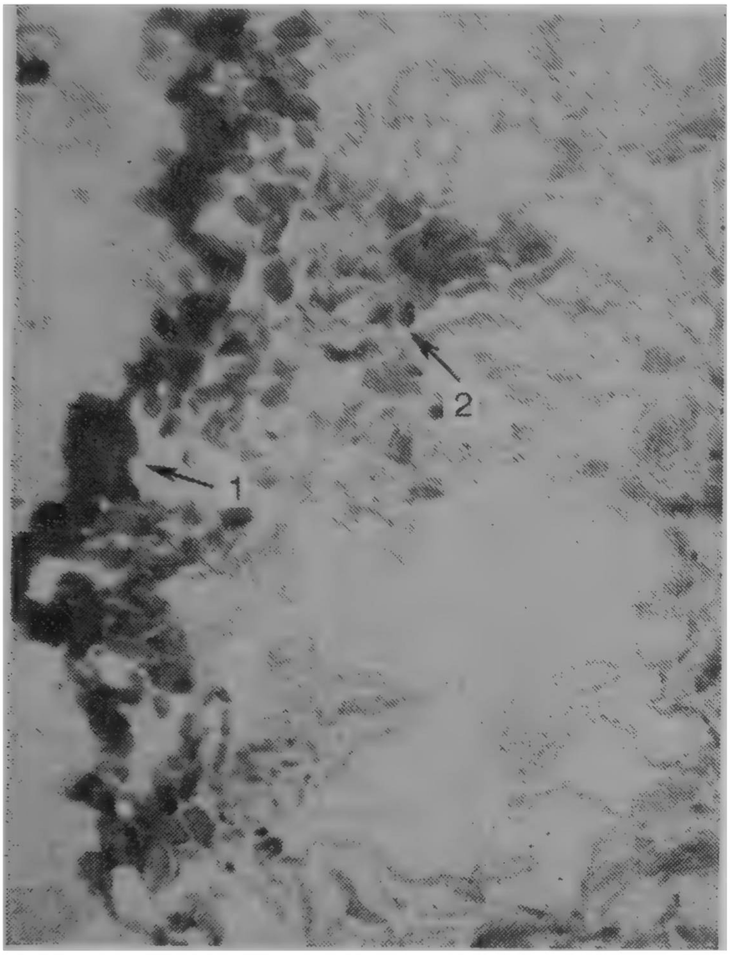


Fig. 18. Osteoarthrosis deformans and secondary synovitis. Structural morphologic alteration of the synovia associated with 40 nCi/l radon baths:

1—lower acid phosphatase activity in synoviocytes; 2—isodye test for acid phosphatase.

The segmental structure of the cartilage was absent, and its surface had fissures. Apart from the structure-devoid sites, there were significant areas of irregularly located chondrocytes in the interstitial substance, or chondrocytes were clustered in a single capsule. The cytoplasm of chondrocytes was PAS-positive, pyroninophilic, and displayed a moderate activity of redox enzymes. The intercellular substance at proliferative sites was PAS-positive and metachromatic upon toluidine blue staining. Numerous chondrocytes had pyknotic nuclei and foamy cytoplasm. Fibrils of the basic substance and small cysts were seen in the 3rd and 4th segments. Some of the cysts showed proliferation of chondrocytes whose cytoplasm was highly PAS-positive (Fig. 17).

To find out morphological changes induced by baths with radon concentration of 40 nanocurie/l in patients with osteoarthrosis deformans and secondary synovitis, 20 puncture biopsy specimens of knee-joint synovial membrane obtained during advanced and chron-

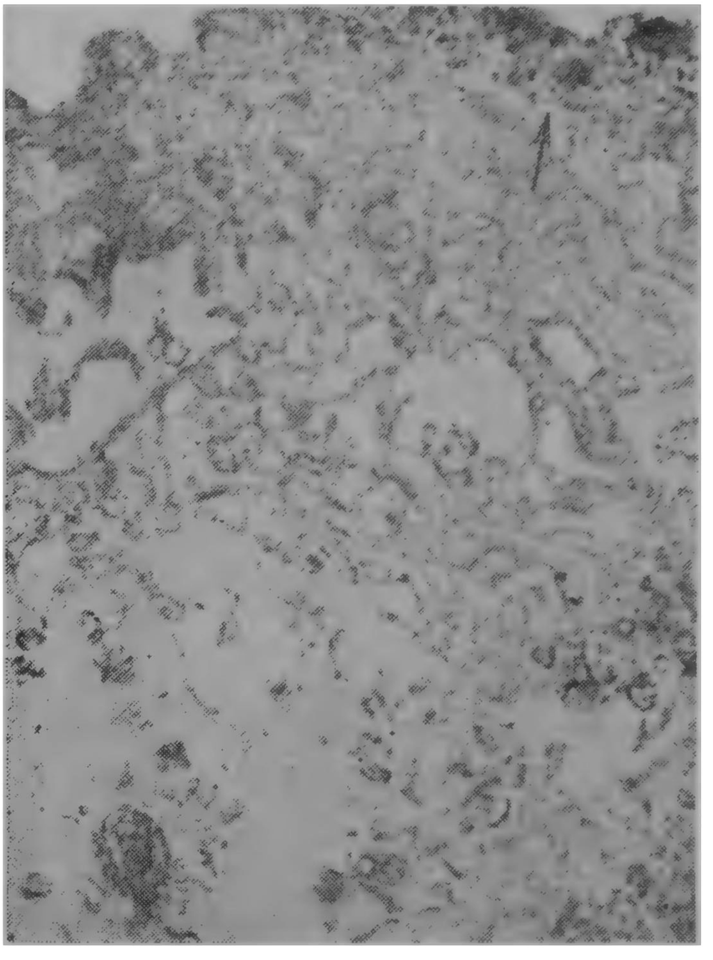


Fig. 19. Moderate lactate dehydrogenase activity in synoviocytes (shown by arrow). Haematoxylin and eosin; × 200.

ic stages were examined by Arutyunov. Inflammatory regression was found in all cases. Synoviocytes were small, cube-shaped or elongated; they had a slightly pyroninophilic cytoplasm with a moderate activity of acid phosphatase and oxidation enzymes (Figs. 18 and 19). Cytophotometric analysis showed a statistically significant reduction in synoviocyte lactate dehydrogenase and acid phosphatase activity ($P < 0.05$). Synoviocytes were absent in some areas. Excessive vascular permeability was reduced. These changes were especially distinct in alkaline phosphatase test. However, mean volume proportions of vessels did not decrease. Synovial sites of initial regression showed marked sclerosis, with no significant changes.

Direct correlations were established between clinical alleviation of secondary synovitis, improvement of biochemical indices of inflammation activity, and morphological changes. Pain was reduced during physical activity, walking up and down the stairs, the locomotor function was improved, trophic processes were enhanced, and symptoms of active secondary synovitis were considerably diminished

or terminated in 49 of 52 patients treated with baths with radon concentration of 40 nanocurie/l. On the other hand, improvement was noted in a smaller proportion of patients and it was less marked in radon therapy using a concentration of 120 nanocurie/l. Pain was reduced only in 26 of 58 patients, and in 32 patients it was slightly reduced. Patients poorly tolerated therapy using greater concentrations. In one group of patients receiving low-concentration radon baths, a balneopathologic response was seen in 5 persons only, while in another group receiving high-concentration baths, it occurred in 18 patients. The treatment was interrupted for 1-2 days and reinstituted thereafter.

Therefore, the alteration of major clinical criteria of the degenerative process, biochemical and morphological data brought about by the radon baths of different concentrations enables us to view their therapeutic effect in arthrosis deformans from a newer perspective and to define indications for using them.

13.2 Physical Methods of Treatment and Rehabilitation of Patients with Rheumatoid Arthritis

Successful treatment of patients with rheumatoid arthritis (RA) is largely determined by the knowledge of mechanism of the pathological process, the causes of its recurrence and progression, the basis of therapeutic action of employed drugs, and the methods of prophylactic and rehabilitation therapy.

During recent decades, the theory of an infectious (streptococcal) origin of RA has become the most accepted, especially among the scientists of this country. According to this theory, the disease is triggered by haemolytic streptococcus A (Nesterov, 1959; Tsarfis, 1960; Tokmachev, 1976).

An exacerbation of chronic infection in the tonsils, carious teeth, accessory nasal sinuses leads to sensitization of the organism. Contributing factors like common chills, physical or emotional strains cause allergy, with arthritis and polyarthritis as its clinical manifestation. However, utilization of desensitizing and bacteriostatic drugs, even antibiotics, fails to control the clinical course, except for the alleviation of severity of focal infection. Inflammation of the joint advances, involving increasingly more joints, affecting the visceral organs, and disabling 30-40 per cent of patients within 2-3 years. This motivates scientists to probe for new ways and methods to trace the pathogenesis of RA and devise the most effective methods of treatment and rehabilitation of patients.

Advances in the investigation of immune processes in RA and the discovery of the rheumatoid factor (RF) as an autoantibody to the homologous IgG have provided support for the auto-immune

concept of this disease, assigning a major role to an immune response to various stimuli, not necessarily infectious.

Utilization of electron microscopy and immunofluorescence has established links between certain chronic arthritides, including sero-negative RA, and asymptomatic infection. During recent years, the relationship between *Mycoplasma* organisms and RA has been explored. Some investigators (Jansson et al., 1971; Jansson, 1975) have succeeded in detecting *Mycoplasma* in the joint tissue, although it might be only a human saprophyte. Glynn (1976) suggested the obligatory role of microbial agents in adjuvant arthritis, regardless of their species.

It is accepted in Finland and other Scandinavian countries that *Yersinia enterocolitica* plays an important role in the development of arthritis, capable of causing enteritis and acute polyarthritis, sometimes transforming into chronic polyarthritis with the presence of the rheumatoid factor in blood. In the opinion of Larsen (1979), reinfection with or persistence of *Yersinia* endotoxin causes an immunologic imbalance and autoimmunization. Neumark and Farkas (1971) detected virus-like inclusions in the synovial membrane cells, although it was asserted by Hart (1977) that no one has been able to isolate the virus from the synovial membrane or fluid.

The aetiologic role of Epstein-Barr virus in RA has been explored by Hart et al. (1979) and Bardwick et al. (1980).

Barland (1973) emphasized the role of a latent virus infection which can induce the synthesis and secretion of great quantities of noninfectious yet antigenic proteins in the hosts's cells or cause the production of new antigens (autoantigens). It has been previously stressed by Phillips (1971) that the 'rheumatoid' virus represents a new type of agent, with no method available for detecting it.

The interest attracted by the infection theory is explained by the major gap in the otherwise consistent concept of immune disorders as the pathogenetic basis of RA: the uncertainty about the primary agent triggering immune responses. Studies on the early stages of RA have shown that it is often clinically similar to other acute, including infectious, arthritides, and immunologic and histologic studies may show very mild abnormalities, if compared to advanced-stage RA, or no abnormalities at all. The rheumatoid factor is usually revealed beyond the early stage, too.

According to Glynn (1976), two phases may be differentiated in the development of RA. The first phase is the spreading of the infection throughout the whole body with a tendency to localize in the joints where inflammation occurs as a result of the local immune response. This period may continue for months, resulting in gradual elimination of antigens. Persistence of active disease or its becoming chronic may, in theory, be explained either by reinfection or the onset of the second phase—autoimmunization. The time of onset of the

second phase and the likelihood of the onset are dependent on the features of immunologic reactivity.

A great pathogenetic significance in RA has been attached to immunopathologic processes: immediate and delayed type hypersensitivity.

Rheumatoid arthritis has been categorized by Serov (1981) under immune complex diseases associated with circulating immune complexes antigen-antibody. In his opinion, immune complex diseases are induced by (1) qualitative features of the immune complexes which are dependent on antigen properties and genetically determined mode of the immune response; (2) impaired functional activity of mononuclear phagocytes eliminating the immune complexes (inborn deficiency, competitive blockade of cell receptors due to hyperproduction of the immune complexes, humoral synthesis of phagocytosis inhibitors, and effect of drugs). The immune complexes can induce immediate and delayed hypersensitivity which may alternate as inflammation develops.

Humoral immunity disorders are the best investigated disorders in RA. Sera of 80 per cent of RA patients are positive for a macroglobulin (termed RF) which represents an antibody to Fc-fragment of IgG. The 'classic' RF which is analysed with the Waaler-Rous and latex tests represents IgM with a sedimentation constant of 19S (Svedeberg's units). Besides Pope and McDuffy (1979) have identified other types of RF—IgG and IgA. Rheumatoid arthritis is said to be seropositive if RF of the IgM type is detected with the above tests, and to be seronegative if it is absent. In the opinion of Hay et al. (1979), Pope (1979) and Allen (1981), RF of the IgG type does not circulate freely in blood but is incorporated by the immune complexes both in seropositive and seronegative patients. The presence of RF (IgG) has been implicated in vasculitis, subcutaneous rheumatoid nodules, and systemic affection of the connective tissue.

It has been pointed out by Speransky (1983) that mean concentrations of the major immunoglobulins (IgG, IgM, IgA) in blood serum and synovial fluid are much higher in seropositive RA, as compared to seronegative. It was suggested by the author that immunoglobulin biosynthesis is promoted by RF. The rheumatoid factor of the IgM type (IgM-RF) is thought by Jamasaki and Liff (1976) to intensify complement-mediated synthesis of immunoglobulins by aggregated globulin-stimulated lymphocytes.

It has been stressed by Pope and McDuffy (1979) that the content of IgG-RF is significantly enhanced in seropositive RA, and an elevated IgM-RF content correlates with the onset of vasculitis and active inflammation. On the contrary, no close correlation was noted between IgM-RF or its levels and activity of the disease. Therefore, the role of IgG-RF lies in its ability to produce by self-binding the IgG-IgG complexes and to activate the complement system.

The epiphyseal cartilage is normally nourished by the synovial fluid on an osmotic basis, whereas in RA the fluid is mixed with the inflammatory exudate having a lot of protein (450 g/l) and leukocytes, predominantly neutrophils. Haemolytic activity of the complement is strongly depressed in the synovia. These facts are of great significance for diagnostic differentiation of RA from various other diseases of joints. Furthermore, the numbers of T-lymphocytes bearing IgG-Fc receptors are decreased in the synovial fluid, suggesting a lower suppressor function of T-lymphocytes. This was interpreted by Natvig and Malbye (1979) as evidence of impaired control by T-cell immunity. Half of all patients with RA exhibit imbalance in peripheral T- and B-lymphocytes counts, with a 10 per cent increase in T-lymphocyte numbers and a simultaneous 40 per cent decrease in absolute numbers of B-lymphocytes. It is worthy to note that moderate and severe rheumatoid activity is commonly (up to 90 per cent) found in these patients.

Using an immunofluorescent test, Kazakova (1970) discovered RF in the rheumatoid synovial membrane, and Winchester (1975) demonstrated an immunomorphologic RF in 20-70 per cent of IgG-producing cells. However, because of its presence in numerous other diseases (lepra, syphilis, systemic lupus erythematosus, sarcoidosis), and even in healthy, particularly, elderly persons, RF is hesitantly qualified as RA-specific. According to Lavrova (1978), the critical step of immunopathologic reactions in RA is immune complex formation with the participation of anti-IgG, i.e. rheumatoid factors. The immune complexes are formed by the antigen (the patient's aggregated IgG) reacting with the antibody (IgM-RF in seropositive RA and IgG in seronegative RA). The immune complexes formed in the synovial membrane and synovial fluid give rise to a series of complements, such as C56, C6-C7, C5a (anaphylotoxin), and the chemotaxic factor C567 which attracts neutrophils. The immune complexes may be engulfed by neutrophils and synoviocytes, thus causing the release of lysosomal enzymes altering the synovial tissue. Cooke et al. (1975) identified the immune complexes in 92 per cent of biopsy specimens of chondral collagen tissue. Excess serum levels of the immune complexes were found in over 60 per cent of patients with RA, and those in the synovial fluid in about 90 per cent.

At present, numerous studies by Soviet and foreign scientists show that cellular immunity plays a role in the pathogenesis of RA. Olhagen (1975) and Arustamova et al. (1976) point out the relationship between the RA activity and the reduction of T-cell numbers in the peripheral blood and elevation of them in the synovial fluid.

According to Voitenok (1980), T-lymphocytes have immunoregulatory functions and ensure local immune reactions. Adaptive cellular immunity has two major components: (1) delayed hypersensitivity and associated immune manifestations, (2) cytotoxic activity of

killer T-lymphocytes. A series of soluble mediators, lymphokines, are released by T-lymphocytes effecting delayed hypersensitivity. This opinion is shared by Maini (1979), Roux and Mercier (1979), Ziff (1979), and Lozovoy, Shirinsky (1981).

Delayed hypersensitivity mediators released by T-lymphocytes aggravate the inflammation and damage the surrounding tissues. Fibroblast- and osteoblast-activating factors are responsible for connective tissue outgrowth, granule formation, and fibrosis. A close relationship has been revealed between macrophages and lymphokine-producing T-lymphocytes; the macrophage membrane bears receptors for the macrophage migration inhibition factor. The macrophages largely contribute to the mechanisms of inflammation by releasing various proteolytic enzymes: plasminogen activator, collagenase, elastase, complement components, prostaglandins (Voitenok, 1980). A lower suppressor function of T-lymphocytes in RA and activation of T-helpers and the humoral response of Ig-producing B cells have been reported by Chattopadhaya et al. (1979).

In discussing the available data on immunopathologic abnormalities underlying RA, it should be emphasized that the regulation of the immunogenesis includes system interactions, first of all neuroendocrine.

A 24-hour evaluation of RA patients for multiple immune and endocrine parameters comprising the circadian periodicity of absolute counts and percentages of T- and B-lymphocytes has revealed distinct discordance of migration and recirculation of immunocompetent cells related to hormonal levels in the adrenal cortex. Immunodepressive effect of androgenic hormones at different levels of the humoral and cellular immunity and lower secretion of these hormones in RA patients have been discovered. No doubt, corticosteroids have immunodepressive effect, and their levels are reduced in patients with chronic RA. Evidence that not only joint elements but the nervous and adaptive systems respond to the onset of sensitization and immune inflammation in RA is provided by multiple neurotic reactions which are clinically manifest as vegetative disorders and alterations in functioning of the pituitary-adrenal, pituitary-thyroid, and sympatho-adrenal systems (Tsarfis, 1980).

It is important to note that these adaptive systems respond to stress stimuli by hyperfunctioning as a protective measure. If, however, the unfavourable factors continuously act on the central and vegetative nervous systems, corticocyte function and 11-oxycorticosteroid secretion are decreased, and the binding capacity of transcortin is increased. It is clearly seen in determining the total, bound and unbound oxycorticosteroids (OCS) by the fractionation method.

The studies by Proskurova in our clinic have demonstrated a parallelism between steroid hormone levels and the activity of RA (Table 12).

As oxycorticosteroid levels in plasma decline, the activity of inflammation increases, transcortin binding capacity is enhanced, and steroid metabolism is depressed. Thus, there is a direct relationship between the decrease in the corticocyte function and the increase in the severity of inflammation.

As steroid hormone, especially free oxycorticosteroid, levels drop, cell membrane rigidity decreases, steroid metabolism is depressed, and inflammatory exudation is intensified.

Therefore, the clinical manifestations of hypocorticoidism parallel plasma oxycorticosteroid levels and activity of inflammation.

Table 12. Oxycorticosteroid Levels in Patients with RA of Different Activity

Inflammation activity	No. of patients	11-oxycorticosteroid levels (μg %)			Transcortin-binding capacity (μg %)
		Total	Protein-bound	Unbound	
Maximal	100	13.1±0.8	12.15±0.3	0.95±0.5	16.6±0.6
Moderate	80	12.2±0.8	11.4±0.2	0.80±0.6	17.8±1.7
High	60	11.6±0.9	11.0±0.6	0.60±0.3	18.6±0.8
Normal subjects	30	15.5±0.51	13.9±0.54	1.60±0.11	15.7±0.52

The levels of 11-oxycorticosteroids in plasma are lower, transcortin level is higher, and the exudation is greater in clinically prominent hypocorticoidism. These data represent unambiguous evidence of pituitary-adrenal involvement in the clinical manifestations of the disease. The reduction in steroid hormone levels in patients is not accidental, since 11-oxycorticoid levels are reduced not only in plasma but in the synovial fluid, i.e. in the inflammation focus. Steroid hormone levels in the exudate of the inflamed joint are 3-4 times lower than those in plasma, and OCS levels in the homogenate of joint-adjacent muscular tissues are 1.5-2 times lower.

Apart from skeletal muscle myoysis, interstitial myositis and synovitis, productive vasculitis and focal infiltrates containing lymphoid and plasma cells occur in muscles of patients with RA. Simultaneously, activity of aerobic enzymes, primarily succinate and malate dehydrogenase, is depressed, while α-glycerophosphate dehydrogenase activity remains high in these cells.

As the rheumatoid process is activated, mucopolysaccharide accumulation, metachromasia on toluidine blue stain, positive Schick's test and focal picrinophilia upon van Gieson's stain are observed at sites of mucoid swelling and fibrinoid necrosis. Such morphological changes in tissues indicate an increased permeability of capillary basement membranes and intensified exudation. Inflammation in

skeletal muscles and locomotor impairment are aggravated by these exudative and cellular abnormalities. Mast cells with β-metachromasia, appearing in inflamed sites, act as chemical mediators which aggravate this process. High activity of acids, alkaline phosphatase and proteinase are found in such cases. Activity of redox enzymes, especially those of NAD-diaphorase, succinate and malate-α-glycerophosphate dehydrogenase, is decreased in 65 per cent of RA patients, while lactate dehydrogenase activity is depressed. Activity of α-glycerophosphate dehydrogenase is increased as RA activity intensifies.

Therefore, anaerobic enzyme activity is increased, and aerobic enzyme activity is decreased in RA.

Apart from hexose, C-reactive protein levels and ESR, changes in basophil leukocytes and lymphocytes are of great interest as they indicate inflammatory activity in RA. It has been demonstrated by Movet (1975) and Myshkin and Denisova (1979) that, like mast cells, the basophils are major donators of bradykinin, histamine, heparin, and serotonin which are involved in allergic and inflammatory processes. The release of biologically active substances from basophils is accompanied by alterations of their morphological structure ranging from the slightest metachromatic granule depletion in the cytoplasm to cell destruction. The release of the biologically active substances, having ion bonds with the heparin-protein complex in the granules, occurs in two ways: (1) as their displacement by extracellular cations (mainly calcium and sodium ions) on an ion exchange principle, with the complement system activation, and (2) as antigen-antibody interaction, with subsequent injury to the cytoplasmic membrane. Based on the results of their study, Gracheva et al. (1983) recommend differentiation of the basophils into three groups according to the metachromatic granule distribution in the cytoplasm: granules that are evenly distributed in the cytoplasm; granules that are located mainly in the peripheral cytoplasm; degranulated basophils (granule-depleted, locally destroyed cytoplasm). Proceeding from this classification, we have proved a relationship between the severity of inflammation and the degree of morphological changes of the basophils in patients with RA. In a more active rheumatoid process. there are a greater reduction in the absolute number of basophils per 1 μl of blood and a significantly greater number of degranulated basophils.

Besides, it was found out that IgM and IgG titres rose with the activation of the rheumatoid process. The comparison of immunoglobulin and rheumatoid factor concentrations with the incidence of degranulated basophils yields a close correlation. The greater the inflammatory activity, and the higher the IgG and IgM concentrations, the lower the absolute basophil numbers, and the greater the basophil degranulation. This suggests that immune mechanisms de-

termining the course of rheumatoid inflammation contribute to the alteration of basophil morphology.

Lymphocyte function is of paramount importance in the development of inflammation. Our joint studies with Sokolova, Zubkova and Nabieva have shown that physicochemical alterations of the lymphocyte membrane and functional and structural abnormalities of the nuclear chromatin are closely related to the course of RA. The content of T-lymphocytes was found to be lower by 51.2 per cent ($P < 0.005$) in the blood of patients with seronegative and by 60.6 per cent in patients with seropositive form of the disease; on the contrary, B-lymphocyte counts were increased by 93 per cent and 125 per cent, respectively. Similar findings were obtained with IgG and IgA, with a greater increase in their levels in seropositive RA. There was a significant difference in IgG and IgA levels in the two groups of RA patients.

An analysis using the readings of fluorescence intensity of 7-n-methoxybenzylamine-4-nitrobenzoxadiazol (MBD) dye, binding to hydrophobic membrane sites, is extensively employed for structural-functional evaluation of lymphocyte membranes. The dye is used in a concentration of 10^{-5} M; the measurements are usually taken in a Hitachi MPG-4 spectrophotometer at 450 nm (excitation wavelength is 484 nm). The structural-functional status of lymphocyte nuclear chromatin can also be assessed by microfluorimetry by binding chromatin DNA to acridine orange (AO). The intensity of fluorescence of chromatin DNA-AO complex is analysed in a MPG-4 spectrofluorimeter at 530 nm, and is expressed in arbitrary units.

The levels of fluorescence of lymphocyte nuclear deoxynucleoproteid (DNP) which are determined by the adsorption of fluorescing AO dye on chromatin DNA varied in the two groups of patients: in patients with seronegative RA, they were 72.5 per cent higher than those in normal donors ($P < 0.001$), while in patients with seropositive RA, they were 20.8 per cent below the normal values ($P < 0.005$). The difference in the values of the two groups was statistically significant ($P < 0.001$). These findings indicate that the content of chromatin in lymphocyte nuclei and the protective function of chromatin are strongly reduced by the ongoing immune inflammation; vice versa, the content of chromatin in lymphocyte nuclei is slightly reduced in a mild course of RA. In uncomplicated steroid metabolism, the protective functions of lymphocytes remain intact, and they aid in the alleviation of immune inflammation. It should be borne in mind that binding of chromatin DNA by these cells is much lower than that in persons with severe immune inflammation. Clinically and biochemically, the inflammation in such patients is compatible with moderate degrees of activity of rheumatoid process. It was also found that absolute lymphocyte numbers per 1 ml of plasma were significantly lower in RA patients than in normal

persons. The structural-functional parameters of lymphocyte chromatin appeared to parallel RF titres. Adsorption of AO by lymphocyte chromatin DNA is greater in patients with low RF titres. This is indicative of conformational alterations in DNA, resulting in more free sites on chromatin DNA, made available by the weakening of DNA bonds with proteins. Such alterations suggest a higher matrix activity of lymphocytes, causing an intensification of synthesis RNA proteins, in particular that of protein enzymes.

The genome of peripheral lymphocytes is more active in patients with seronegative RA, as compared with patients with seropositive arthritis. The latter patients experience a more severe clinical course and repressed genomes: DNA of lymphocyte chromatin is more blocked than in normal patients and seronegative RA persons.

Examination of lymphocyte membranes showed the relative MBD fluorescence to range in RA patients from 0.01 to 0.55 arbitrary units, varying from 0.07 to 0.15 units in 46 per cent of patients. In donors, MBD fluorescence intensity related to structural-functional changes of the lymphocyte membranes amounted to 0.18 to 0.27 of an arbitrary unit. This value tended to decrease in patients with seronegative and to increase in patients with seropositive RA. Corticosteroids, especially unbound ones, play a substantial role in the mentioned processes, since they make cell membranes rigid. The greater the corticoid deficiency, the greater the permeability of membranes and, consequently, their structural and functional abnormalities. The results of these studies have important clinical implications, since they help understand the mechanisms of immune inflammation and may be used as markers of its course and abnormalities occurring on cellullar levels.

Cellular allergic reactions are accompanied by an impairment of oxidation processes which are markedly enhanced by the activation of the hormonal link of the sympatho-adrenal system. Antibacterial action of phagocytes is associated with the cytopathic effect of the peroxidase system, cation proteins of primary neutrophil granules, and with lymphocyte accumulation of glycogen as energy material for metabolic processes in the phagocytic cells.

Non-specific immune reactivity, especially phagocytic function of the macrophages, is diminished in experimental allergic arthritis with decreased peroxidase activity of leukocytes. However, the non-specific reactivity is enhanced and serves as protection against the disease in patients with RA.

The status of the pituitary-thyroid system plays an important role in the clinical course of RA. Our observations of many years show that functional activation of the thyroid is much greater in acute local infection than in latent course of the disease. The immunologic alteration associated with metabolic processes causes the functional activation of the thyroid. The change in the thyroid function tells on the

clinical course by modifying basal metabolism, oxygen consumption in tissues, primarily those of the affected joint, and by reducing lymphopoiesis and systemic reactivity.

Special studies have indicated the uptake of ^{132}J to be normal in 41.1 per cent of patients with RA, to be elevated in 41.1 per cent, and to be decreased in 17.8 per cent. Notably, radiosensitive methods used detected functional disorders of the thyroid 2.5 times more frequently than clinical methods did. Thyroid hyperfunction was common in persons below 40 with moderate activity of inflammation. Thyroid hypofunction was usually found in persons above 60 with proliferative component of inflammation prevalent over the exudative.

These functional alterations of the pituitary-adrenal, pituitary-thyroid and immunocompetent systems largely determine the clinical and morphological features of RA.

Clinicomorphological Features of Rheumatoid Arthritis

To understand the complexity of this severe disease and to use physical methods for its treatment appropriately, it is necessary to survey briefly the results of clinical and morphological studies. A total of 714 patients with RA, predominantly females (83.3 per cent), were under our observation. Most patients (72.4 per cent) had joint disease, the rest (28.6 per cent) had visceral and combined clinical forms of the disease.

Locomotor function was found to be impaired in 73.5 per cent of all patients. Patients with moderate activity of the disease constituted 45.1 per cent, those with minimal activity—54.9 per cent. A greater incidence of articular-visceral involvement and more severe functional disturbances of joints were noted in the moderate activity of the disease. The distribution of patients by stages was based on X-ray findings: stage I is characterized by periarticular osteoporosis and mild narrowing of the joint slit; stage II by moderate bone and cartilage destruction manifested as joint slit narrowing and solitary caries. Significant destruction of the bone and cartilage manifested as marked joint slit narrowing and multiple caries, and local bone necrosis and lysis are seen in stage III. In addition to the abnormalities of stage III, fibrous ankylosis and diffuse necrosis and sclerosis of the bone tissue are observed in stage IV. Stages III and IV were prevalent in patients with moderate activity of the disease.

Diagnostic criteria of the American Rheumatism Association (Ropes et al., 1959) were employed by us in the diagnosis of RA and evaluation of its accuracy. Distribution of patients according to the ARA criteria of RA activity and stages is represented in Tables 13 and 14.

Ten ARA criteria for RA-specific clinical, X-ray, biochemical, and

histologic alterations are used in making the diagnosis. RA is diagnosed as 'classic' if 7 criteria are met, 'obvious' if 5 criteria are met, and 'likely' if 3 criteria are met. 'Classic' RA was diagnosed in stages III and IV in 57.9 per cent of patients and in moderate activity

Table 13. Activity-Specific Distribution of Patients with Rheumatoid Arthritis (RA) According to the Criteria of the American Rheumatism Association

Disease activity	Diagnosis of RA		
	Likely (%)	Obvious (%)	Classic (%)
Mild	2.9	20.6	31.4
Moderate	—	8.8	36.3
Total	2.9	29.4	67.7

of the disease in 36.3 per cent of patients, while 'likely' RA was noted in minimal activity of the disease and in stage I. This additionally supports the fact that RA is more manifest in high activity and severe progress of the disease.

A clinically combined form was revealed in 11.8 per cent of patients, of whom 63 per cent were elderly.

Accompanying diseases were hypertension (in 9.8 per cent), ischaemic heart disease (cardiosclerosis) (5.9 per cent), gastric and duode-

Table 14. Stage-Specific Distribution of Patients with RA According to the Criteria of the American Rheumatism Association

RA stage	Diagnosis of RA		
	Likely (%)	Obvious (%)	Classic (%)
I	2.9	17.7	9.8
II	—	10.8	22.6
III	—	0.9	22.6
IV	—	—	12.7
Total	2.9	29.4	67.7

nal ulcer (3.9 per cent), chronic gastritis (4.9 per cent), chronic pneumonia (5.9 per cent), chronic cholecystitis (16.7 per cent), osteochondrosis and deforming spondylosis (9.8 per cent), chronic colitis (10.8 per cent), non-specific ulcerous colitis (0.9 per cent), renal stone disease (1.9 per cent), chronic pyelonephritis (0.9 per cent), stage II obesity (1.9 per cent), and neurodermitis (0.9 per cent).

The cardiovascular status plays a significant role in the response to physical therapy, and thus the ECG examination should be given to all patients, in addition to the clinical one, at the beginning and at the end of therapy. The pretreatment ECG is found to be normal in 24.5 per cent, and abnormal in 75.5 per cent of all patients. An impairment is usually seen in the automatic function: tachycardia in 18.8 per cent of patients, bradycardia in 10.8 per cent, arrhythmia presenting itself as single extrasystoles in 3.9 per cent of patients. Diffuse abnormalities of the myocardial ventricles were observed in 23.5 per cent of patients; left ventricular hypertrophy was noted in 15.7 per cent, and abnormal conductance presenting itself as a blockade of the bundle of His in 6.3 per cent. Disorders associated with overload of pulmonary circulation were revealed in 2.9 per cent of cases.

Multiple joint involvement is characteristic: polyarthritis was diagnosed in 91.3 per cent, and oligoarthritis in 7.8 per cent of patients. Monoarthritis with the involvement of knee joint was seen in a minor proportion of cases.

Prolonged drug intake (1 to 5 years) is common in patients. Prior to hospital admission, 52.9 per cent of patients with moderate rheumatoid disease had been treated with anti-inflammatory non-steroid drugs, and 18 per cent of patients experiencing moderate disease activity received hormones. Drugs must not be withdrawn upon hospital admission if an exacerbation before the start of balneo- and mud therapy is to be avoided. As the patient's condition improves, drug dosage is reduced near the end of therapy or after it.

During examination patients usually complain of pain of different types in the joints (acute, dull, permanent, periodic, at rest or during exercise) and joint stiffness associated both with pain and proliferative-exudative disorders and fibrous contractures. Chronic joint deformity is noticeable. In some cases, this is related to exudation in the joints or oedema of joint-adjacent soft tissues, e.g., spindle-like enlargement of the proximal interphalangeal hand joints. In some patients, joint deformity is determined by proliferative fibrous abnormalities of the capsule, muscle tendons, and periarticular tissues. Muscular contractures (commonly elbow and knee), joint subluxations, and ulnar displacement of the wrist and metacarpal-phalangeal joints are seen. Similar disorders are observed in the foot joints. 'Rheumatoid' nodules located mainly on the outer forearm near the elbow joint were found in 8.8 per cent of patients. Muscular hypotrophy, primarily that of affected joint-adjacent muscles, was seen in 74.5 per cent of patients.

The advance of the pathological process is characterized by increasing pain which is assessed not only by patient complaints but also by articular index values. The muscular strength of the arms is measured with a spring dynamometer. Morning stiffness continued

for 15 minutes to 1 hour in patients with mild disease, and for 1.5 to 5 hours in patients with moderately active disease.

Since clinicobiochemical abnormalities in RA are a reflexion of neurohumoral regulatory and synovial disorders, clinical and laboratory findings in RA should be compared with morphological changes in the synovial membrane/fluid.

In biopsy specimens of the synovial membrane, examined by us in cooperation with Kopyeva and Balkarova (1983) with due regard for systemic and local activity of the disease, the reliable histologic diagnostic sign—palisade-like location of synoviocytes in relation to fibrinous semi-granulomatous films—was found in only 10 cases of moderately active RA. Probable and secondary signs of active inflammation (significant numbers of lymphoblasts and macrophages

Table 15. Tissue Alterations (vol%) in Patients with Rheumatoid Arthritis According to Disease Activity (means±SD)

Tissue alterations	Disease activity		
	Mild	Moderate	P
Synoviocyte layer (μm)	8.7±0.7	10.1±0.6	0.05
Fibrinous deposits	—	4.1±1.0	0.001
Hyaline deposits	0.9±0.4	0.9±0.3	0.05
Vasculitis, capillaritis	1.3±0.2	4.6±1.1	0.01
Vessels	15.5±1.2	21.4±1.7	0.01
Cell infiltrate	18.5±1.2	34.4±2.8	0.01
Fibrinoid alterations	—	1.8±0.1	0.01
Loose connective tissue	2.2±0.8	4.4±0.6	0.05
Sclerosis	49.4±2.1	19.1±2.7	0.001
Hyalinosis	3.2±1.7	1.2±0.1	0.05
Lipomatosis	9.0±3.2	8.1±2.4	0.05

in the inflammatory infiltrate, proliferation of synoviocytes with high acid phosphatase activity) were seen in all cases of moderately active RA and in some cases of minimally active RA. On the other hand, the probable and secondary histologic signs of regressing local inflammation were detected in all biopsy specimens in mild and moderate disease.

The important histochemical and immunomorphological features of local inflammation are represented in Table 15.

Proliferative inflammatory reaction is predominant in rheumatoid synovitis associated with RA of moderate activity. Exudative changes are less marked: a small proportion of polymorphonuclear cells in the inflammatory infiltrate was found in one-third of all cases,

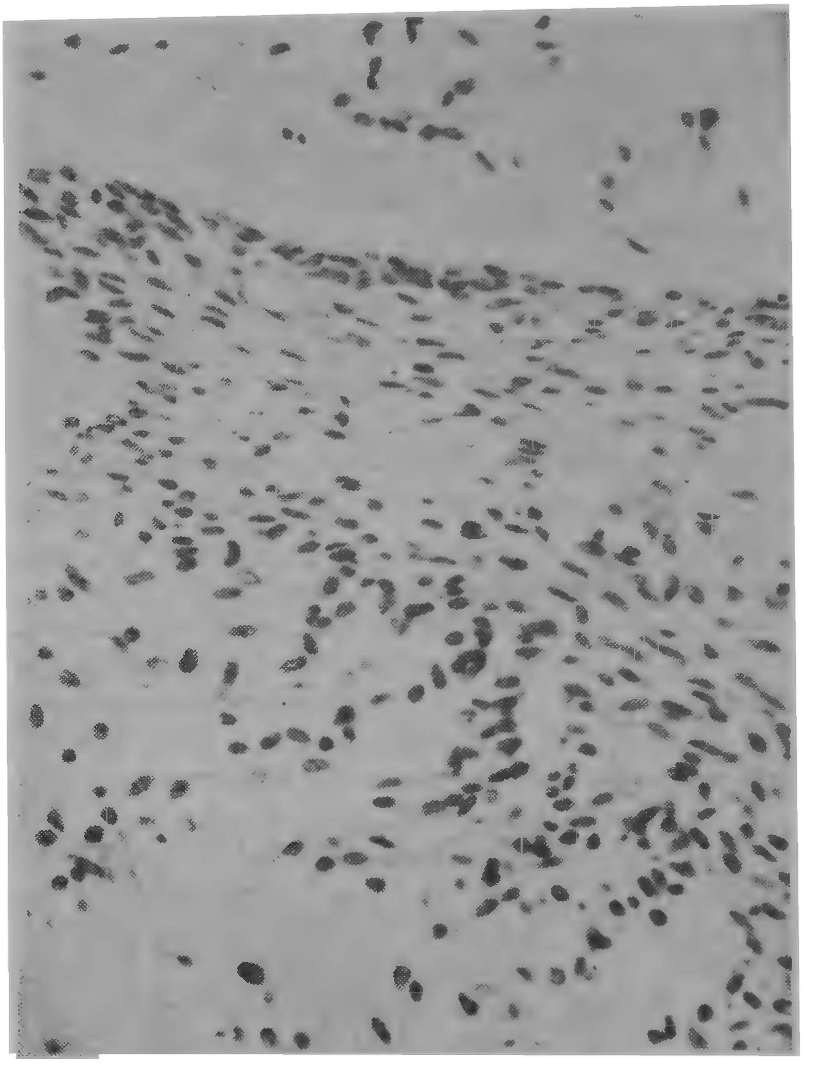


Fig. 20. Biopsy specimen of the synovial membrane of a 36-year-old patient (before treatment). Rheumatoid synovitis of moderate activity. A hyperplastic villus: capillaritis, mild lymphocyte and polymorphonuclear infiltration, massive superficial fibrous deposits. Haematoxylin and eosin stain: × 250.

reduced counts of mast cells were noted in occasional cases, capillaritis and productive vasculitis in one-fourth, and soft fibrinous deposits on the villi in another one-fourth of all cases (Fig. 20).

High alkaline phosphatase activity in the capillary endothelium also indicated increased vascular permeability. Local mucoid swelling and fibrinoid alterations were found only in a small number of biopsy specimens. This might be explained by the absence of marked exacerbations in the group of patients under study.

There were significant volumes of the inflammatory cellular infiltrate: 34.4 ± 2.8 vol% of total structural constituents. Lymphoblasts, macrophages, lymphocytes, plasmocytes and solitary polymorphonuclear cells were found in the infiltrate (Fig. 21). Cellular infiltration around the vessels was seen to be both diffuse and large-

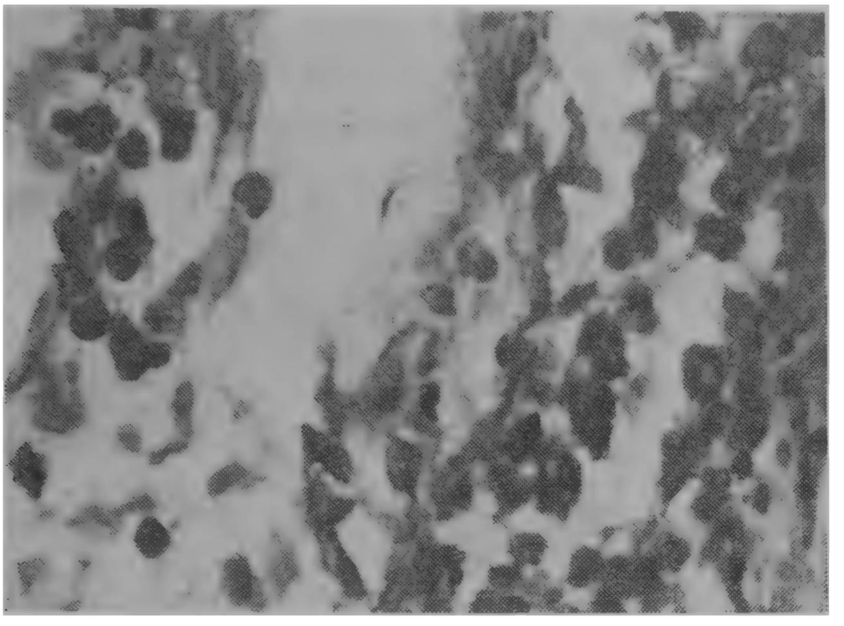


Fig. 21. Biopsy specimen of the synovial membrane of a 53-year-old patient (before treatment). Rheumatoid synovitis of moderate activity. Abundant plasma cells in the infiltrate. Brachet's test; × 400.

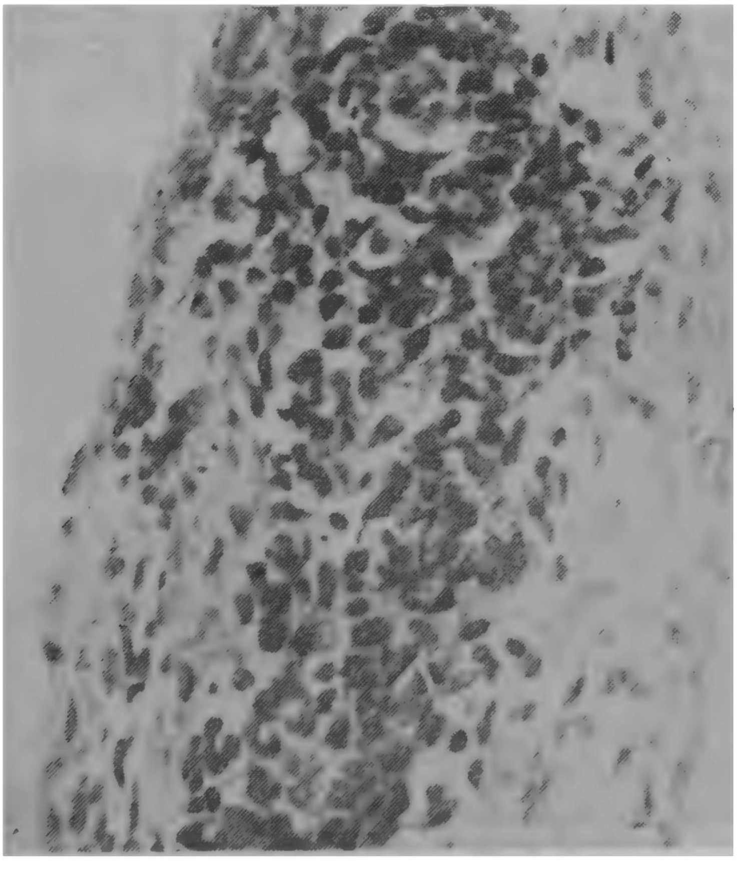


Fig. 22. Biopsy specimen of the synovial membrane of a 46-year old patient (before treatment). Rheumatoid synovitis of moderate activity. Villous hyperplasia, massive diffuse infiltration, with lymphocytes and plasma cells predominant. Brachet's test; × 400.

focal (Fig. 22). Lymphoid follicles were found in a number of cases. Proliferation of synoviocytes was observed (the mean thickness of the layer was 10.1 $\pm$ 0.6 μm). They locally formed 6-7 layers of sparsely arranged cylindrical or cube-shaped cells with high acid phosphatase activity. Their cytoplasm was pyroninophilic in the Brachet test, indicating intense ribonucleoproteid metabolism; in addition, it showed significant activity of NADP-diaphorase and glucose-6-phosphate dehydrogenase (Fig. 23). Furthermore, the synoviocyte cytoplasm had granules which were mildly metachromatic upon toluidine blue staining. This was interpreted as intensified hyaluronic acid production.

Immunofluorescent studies showed IgG and IgM fluorescence in single mononuclear subsynovial cells, synoviocytes, and, extracellularly, in the interstitial tissue; in some cases, specific fluorescence was seen in complement-reactive cells (Fig. 24).

The predominant morphological finding in mild rheumatoid synovitis was the presence of sclerosed hyperplastic villi (Fig. 25). The subsynovial layer was represented by fibrous tissue with fibrocytes prevailing in it; there were emptying of the capillary network and sclerosis of the vascular walls. Scarce infiltrates from solitary lymphocytes and degrading plasmocytes, and solitary mast cells were encountered around some of the vessels. Local hyalinosis and lipomatosis, and hyaline-like films on the villi were consistently observed, although their volume proportions were small. Synoviocytes were small, cube-shaped or elongated, and diffusely observed; the activity of redox enzymes and acid phosphatase was low in them (Fig. 26).

Half of the specimens showed both sclerosed and hyperplastic villi and subintimal outgrowth of the granulation tissue with abundant newly-formed capillaries, venules, and arterioles. Some capillaries had succulent endothelium with positive alkaline phosphatase reaction. Capillaritis and vasculitis were occasionally noted. Volume proportion of the cellular infiltrate was significantly ($P < 0.01$) lower than that in patients with moderate disease activity. The infiltrate was small-focal, perivascular, with mature cells prevailing: plasma cells, lymphocytes. There were solitary macrophages and numerous mast cells either with dense metachromatic granules or degranulated. Fibroblasts and fibrocytes were present in comparable numbers, and had moderately pyroninophilic cytoplasm; some cells positively reacted to acid phosphatase. The villi showed focal proliferation of synoviocytes; they were cube-shaped, arranged in 4-5 layers, and had moderately pyroninophilic cytoplasm with modest activity of acid phosphatase and redox enzymes. Over a great stretch of the villous surface, the synoviocytes made up a single layer. The cytoplasm was mildly pyroninophilic in the Brachet test, with low acid phosphatase and redox enzyme activity. Dense fibrin deposits were seen on its surface, and haemosiderin in the subintimal layer.

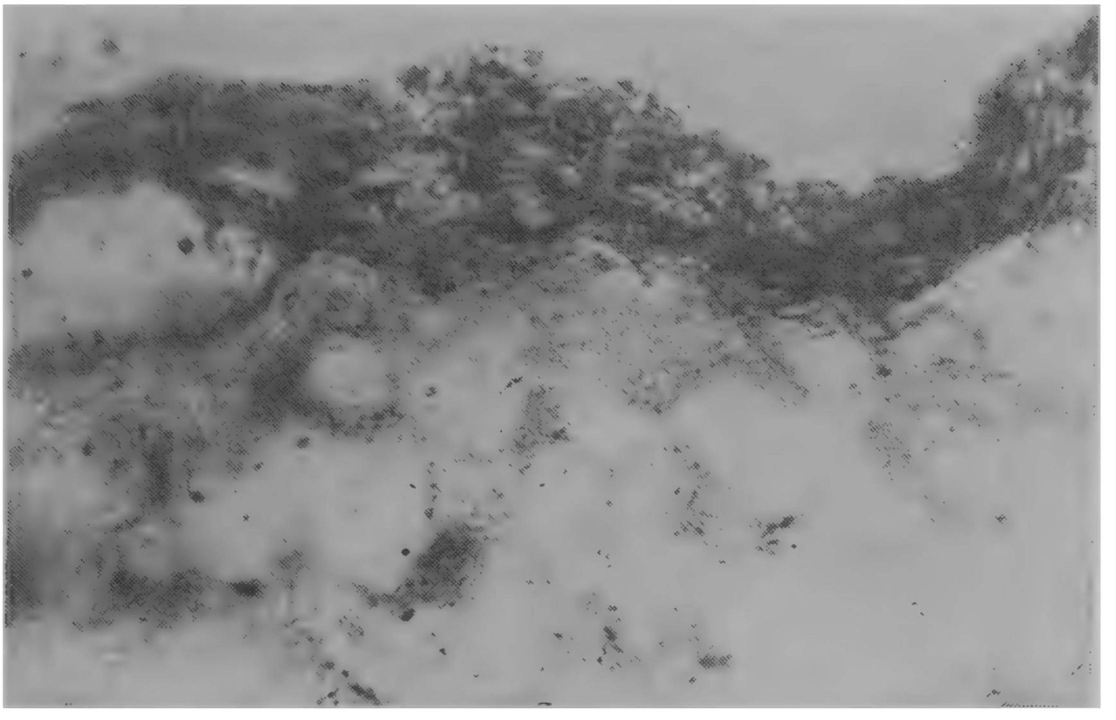


Fig. 23. Biopsy specimen of the synovial membrane of a 59-year-old female patient (before treatment). Moderate rheumatoid synovitis. Moderate activity of NADP-diaphorase in synovial cells and subintimal cells of the vascular endothelium. NADP-diaphorase test; × 140.

Fig. 24. Biopsy specimen of the synovial membrane of a 35-year-old female patient (before treatment). Moderate rheumatoid synovitis. Fixation of IgG in the venular wall. Indirect Coons' test; × 200.

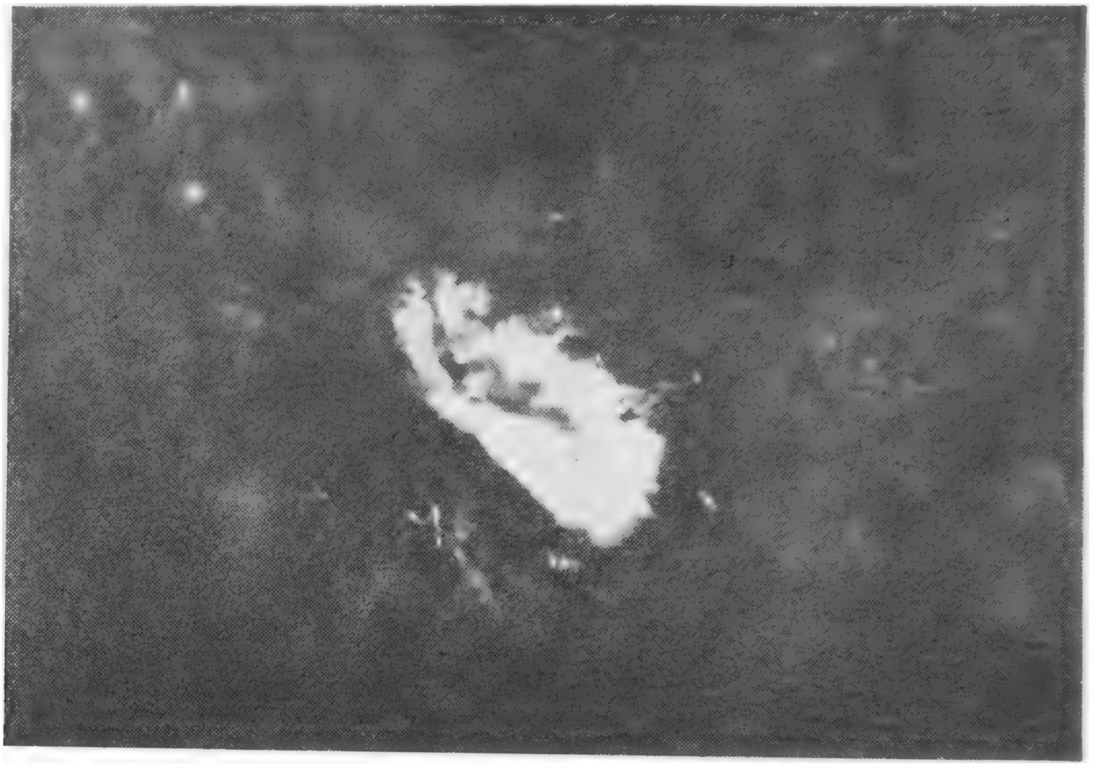
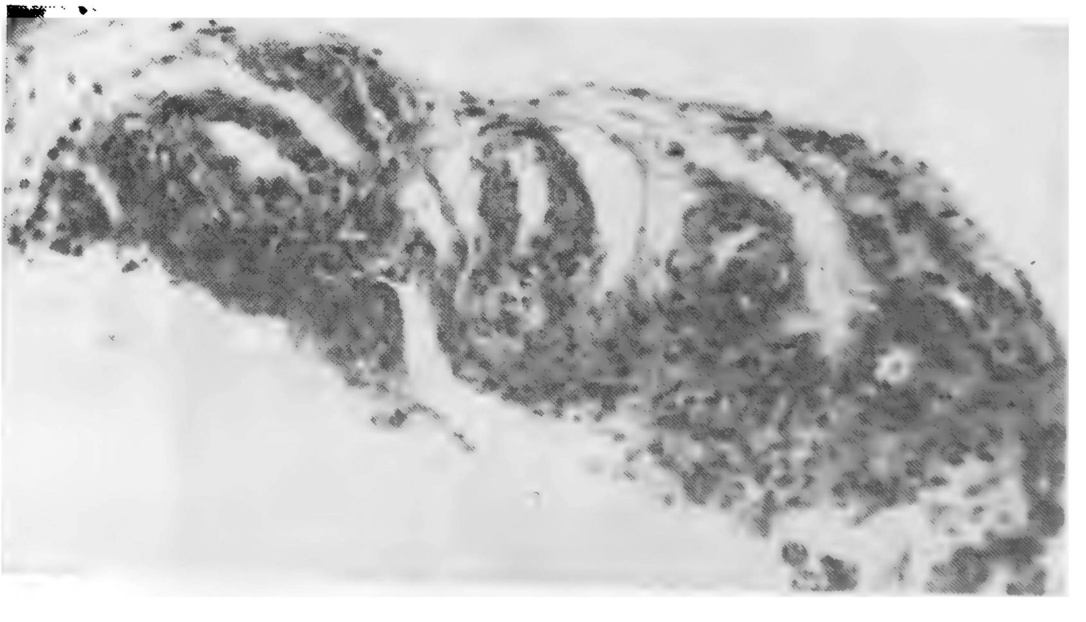


Fig. 25. The same observation. Complement fixation in the venular walls. Goldwasser-Chopard test; × 200.



Immunofluorescent test revealed specific fluorescence of IgA, IgG, and complement-reactive groups.

The tissue alterations in mild and moderate chronic synovitis were corroborated by the findings of histostereometric examination of the synovial membrane biopsy specimens. In moderate activity of the disease, there were greater volume proportions of the inflammatory cellular infiltrate, vasculitis and vessels of the granulation tissue ($P < 0.01$), and greater volume proportions of focal fibrinoid changes, fibrinous deposits on the synovial villi ($P < 0.001$); the synoviocyte layer thickness also tended to increase ($P < 0.05$). Mild synovitis was characterized by a significant ($P < 0.001$) increase in the volume proportion of focal sclerosis.

Therefore, morphological studies using histoenzymochemical, histostereometric and immunofluorescent analyses revealed substantial differences in tissue alterations in mild and moderate chronic synovitis.

In moderate RA, proliferative inflammatory reaction with exudation occurs in the synovial membrane, which is consistent with an immunopathologic process presenting itself as immediate and delayed hypersensitivity. The humoral immune response in the synovial membrane was indicated by plasma proteins, immunoglobulins A, G, M, and complement-reactive groups detected at the affected sites by the immunofluorescent test, and by the presence of plasmocytes, lymphocytes and polymorphonuclear cells in the inflammatory infiltrate. There is indirect evidence of cellular immunity involvement in the mechanisms of tissue damage: significant lymphoid-macrophage infiltration, with acid phosphatase highly active in macrophages. Thus, the synovial membrane alterations in RA represent a multifactorial process associated with the activation of effector systems of both cellular and humoral immunity. Moreover, the results of these studies have demonstrated the complexity of alterations occurring on the cellular and subcellular levels at the onset of immune inflammation. The transformations involve not only cellular structures of the joint but cells of other organs contributing to the onset of the disease. These changes were especially pronounced in lymphocyte and basophil membranes and nuclei, structure and function of corticocytes and thyrocytes, enzymic and metabolic processes occurring far from cellular structures of the joint.

Combined Therapy of Patients with Rheumatoid Arthritis and Ankylosing Spondyloarthritis

Therapy of patients with rheumatoid arthritis (RA) and ankylosing spondyloarthritis (AS) is an urgent and difficult problem. Drug therapy alone does not prevent frequent exacerbations; therapeutic

efficacy is transient, and patients are rapidly disabled. Therefore, utilization of physical methods in patients with RA and AS is of important medicobiological and socio-economic significance.

Even when applied by mitigated methods, balneologic and mud therapy evokes pronounced balneopathologic response in patients with mild activity of the disease. For this reason, at the resorts clinicians combine drugs (that patients were receiving prior to arrival to the resort) with radon/sulphide baths or mud therapy. When supplemented by drugs, these methods of treatment at the resort are more effective.

Combination of radon, sulphide or sodium chloride baths with high or ultra-high frequency electromagnetic wave applications for rheumatoid arthritis has been shown to produce greater therapeutic effect than therapy consisting of natural factors and drugs. This is of crucial importance, since, first, patients with active rheumatoid arthritis for years receive therapy with corticosteroid hormones which, apart from favourable, cause side-effects, thus making break periods extremely important; second, this substitution therapy is known to depress the glucocorticoid function of the adrenal cortex, inducing severe morphological disorders in it and making the patients hormone-dependent. Treatment of the adrenal sites and adjacent sympathetic trunks with high and ultra-high frequency electromagnetic waves leads to higher synthesis of steroid hormones, dissociation of the protein-steroid complex, and release of unbound corticosteroids. The combination of these changes exerts a depressive effect on the immunocompetent system and reduces the permeability of cell membranes, inflammatory exudation, and rheumatoid activity. Exacerbations are prevented even in off-drug periods by combinations of mineral baths and mud therapy with high frequency electromagnetic waves administered with an IKV-4 apparatus or ultra-high frequency electromagnetic waves administered with a Volna-2 apparatus.

Turbulent currents having thermal effect are induced in tissues, primarily those with multiple blood and lymph vessels, by application of the high frequency electromagnetic field to the body. An important contribution is made by the specifically-acting oscillator factor. The tissues are heated by 1-3 °C (depending on the dosage delivered). lymph and blood circulation and metabolism are promoted. leukocyte phagocytic activity is enhanced. enzyme activity is increased. and auto-immune processes are decreased by the application of inductothermy. Blood flow is intensified and prolonged (for 45 minutes after the treatment), blood oxygen saturation is obtained by the heating action of inductothermy. Blood serotonin and histamine levels are increased in patients by inductothermy.

As high frequency electromagnetic waves are applied to the adrenal area, corticocyte counts and deficient plasma levels of free corticosteroids are increased, and dissociation of the protein-steroid complex is

intensified, resulting in a 1.5-2-fold rise of free 11-oxycorticoid levels in blood serum. Stimulation of the adrenocortical function by inductothermy in patients with RA and AS is accompanied by improved functioning of the sympatho-adrenal system, especially its sympathetic link. Activation of total glucocorticoid, noradrenaline and dopamine production plays a great role in decreasing the inflammatory and increasing the trophic activity. The neurohumoral and hormonal

Table 16. Alteration of 11-Oxycorticosteroid Levels in RA Patients by 40 and 120 nCi/l Radon Baths Concomitant with Inductothermy

Physical factors	Pre- and posttreatment 11-oxycorticosteroid levels (μg %)							
	Total		Protein-bound		Unbound		Transcortin-binding capacity	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
40 nCi/l radon baths concomitant with inductothermy	12.1	11.8	11.5	10.6	0.6	1.2	17.9	14.4
120 nCi/l radon baths concomitant with inductothermy	11.2	11.2	9.6	9.6	1.6	1.6	17.4	18.2

alterations have beneficial effect on vascular and neuromuscular systems and on the normalization of the thyroid function. Applied to the adrenal and affected joint areas in RA and paravertebrally along the spine in AS, inductothermy is helpful in inhibiting the immunocompetent system and immune inflammation activity. Inductothermy prevents RA and AS progression, thus acting as secondary prophylaxis.

It has been shown by Grigoryeva (1976) that, apart from the abovementioned changes, dissociation of oxidative phosphorylation is promoted by the electromagnetic decimetre-range field, resulting in a diminished energy supply to the inflamed site. Inhibition of the auto-immune response leads to less destruction of collagen structures of the connective tissue and reduced inflammation activity. This is indicated by the lower levels of C-reactive protein and sialic acids in the blood serum and slower ESR after a course of inductothermy or decimetre wave therapy.

Application of the electromagnetic field to the affected joint area (3-4 coils of the inductor cable around the joint) produces another effect; it inhibits the activity of plasma cells in the synovial membrane and improves the blood supply to the joint. The release in the joint of steroid hormones has a depressive effect on immunocompetent cells, synovial pannus, and other synovial cells involved in inflammation. Severity of arthritis is significantly reduced, and locomotor

Table 17. Alteration of 11-Oxycorticosteroid Levels in Patients with Rheu
with Decimetre-Wave Therapy

Physical factors	11-Oxycorticosteroid levels before			
	Total		Protein-bound	
	Before	After	Before	After
200 nCi/l radon baths	12.0±1.27	11.8±1.27	11.1±1.05	11.6±1.27
200 nCi/l radon baths combined with decimetre-wave therapy	12.2±1.27	13.2±1.27	11.5±0.53	12.8±1.36

function and the general condition are improved as tissue destruction is arrested and steroid metabolism and transport function of proteins are increased. As little as one application of inductothermy resulted in an improvement of the clinical course in 74 per cent of patients; 82 per cent of patients with mild disease, 77 per cent of patients with moderate, and 64 per cent of patients with severe disease appeared to benefit from the therapy. However, therapeutic effect of one inductothermy treatment is transient as it is in substitution hormonal therapy. For this reason inductothermy is combined with radon or sulphide baths, medical exercises, and massage.

Analysis of the alteration of adrenocortical glucocorticoid function according to different radon concentration (40. 120, 200 nanocurie/l) and concomitant inductothermy or decimetre wave therapy has shown that the alteration was greatest and consisted of an increase in free corticosteroid levels and a decrease in the transcortin binding capacity with therapeutic application of 40 nanocurie/l radon baths and inductothermy.

Special studies have been conducted to evaluate the role of each of the mentioned factors in the combined therapy of patients and to validate therapeutic methods using these factors.

To evaluate the alteration of adrenocortical glucocorticoid function in patients treated with inductothermy combined with radon baths of different concentrations and by 200 nanocurie/l radon baths alone, total, protein-bound and unbound 11-oxycorticosteroid levels, and transcortin binding capacity have been examined (Tables 16 and 17).

It may be concluded that the ratios of oxycorticoid fractions are altered (total oxycorticoid levels are decreased while protein-bound ones are slightly increased) and unbound oxycorticoid levels are significantly reduced by radon concentration of 200 nanocurie/l, deleteriously affecting the clinical course of rheumatoid arthritis.

The function of the sympatho-adrenal system was also variably

matoid Arthritis Treated with 200 nCi/l Radon Baths Alone and Combined

and after treatment (μg %)		Transcortin-binding capacity	
Unbound			
Before	After	Before	After
0.9±0.24	0.2±0.13	15.6±2.31	14.9±2.74
0.7±0.19	0.4±0.01	16.0±1.12	14.2±1.74

altered by radon baths of different concentrations or their combination with inductothermy (Table 18). It was more fully restored by inductothermy than by the radon baths. This effect was greater in patients with moderate and severe activity of the disease.

The response of the hormonal link of the sympatho-adrenal system to physical therapy did not always parallel that of the sympathetic link in patients with RA. Baths with radon concentration of 120 nanocurie/l activated the hormonal link of the system in patients with severe inflammation, causing activation of redox processes and deterioration of inflammatory exudation. In patients with moderate activity of the disease, these baths activated the sympathetic link, resulting in trophic improvement, lower proliferation of inflammation, and better locomotor function.

On the other hand, the baths with radon concentration of 40 nanocurie/l caused the most marked change in the functions of the sympatho-adrenal and pituitary-adrenal systems, especially when combined with inductothermy: the hormonal link of the sympatho-adrenal system was depressed and the sympathetic link was activated. These changes are accompanied by the alleviation of inflammation and hypocorticoidism, and the improvement in the general condition and locomotor function.

Clinical observations have shown that iodobromine baths are well tolerated by patients with RA and AS. However, itching is experienced after 3-4 baths in 9 per cent of all patients. The itching also occurs after 8-10 baths. In a small proportion of patients with accompanying atherosclerotic cardiosclerosis and bradycardia (heart rate of 55 per 1 min), unpleasant sensations in the cardiac area and further slowering of the heart rate (to 50 per 1 min) occur. The iodobromine baths are stopped, and sodium chloride, radon or nitrogen-radon baths well tolerated by the patients are prescribed. The heart rate, intracardiac and systemic haemodynamics are improved, and intoxication and inflammation severity are reduced. The therapeutic course has

Table 18. Pattern of Alteration of Catecholamine and Biogenic Amine Levels of Treatment

Therapeutic factor	Catecholamine and DOPA levels before and after treatment (μg/day)					
	Adrenaline		Noradrenaline		Dopamine	
	Before	After	Before	After	Before	After
40 nCi/l radon baths	3.9±0.2	3.7±0.24	12.3±0.65	12.8±0.72	228.9±14.0	229.8±13.6
120 nCi/l radon baths	3.8±0.36	4.5±0.8	11.3±0.6	13.5±0.7	227.8±12.1	248.6±11.4
Inductothermy	4.3±0.37	3.7±0.28	11.2±0.74	12.8±0.68	216.5±10.3	235.7±10.1
40 nCi/l radon baths with inductothermy	4.0±0.17	3.8±0.2	11.5±0.4	12.8±0.54	228.6±11.4	236.7±10.9
120 nCi/l radon baths with inductothermy	4.0±0.22	3.7±0.28	12.1±0.76	14.2±0.72	233.4±8.0	252.0±8.7

a good effect on the patients. Yet irritability, restless sleep and other neurotic responses are induced by such baths in 3 per cent of patients with RA.

The iodobromine baths have a sedative effect in the majority of patients with RA and AS: sleep is improved, intoxication and hypocorticoidism are alleviated, pain is less at rest and upon palpation. Inflammatory exudation is lessened, muscular strength and locomotor function are increased. Moreover, circumferences of inflamed interphalangeal, radiocarpal, knee and other joints are lessened, inflammatory proliferation is diminished, and working ability is improved.

Immediately after a single procedure there is a mean increase in the heart rate of 5-10 beats per 1 min, and a 10-15 mm Hg decrease in the systolic and 5-10 mm Hg in the diastolic arterial pressure (also seen in hypertensive patients). Although the arterial pressure returns to its initial level within 1-2 hours after bathing, a reduction of it is obtained by the end of therapy. Apart from fewer complaints, tachycardia and cardiac pain are diminished, and ECG is improved by the therapy; sinus tachycardia is alleviated, T-wave amplitude, ST segments and QRS complex are enhanced. Inflammation is diminished, and locomotor function is improved by the iodobromine baths.

The number of joints affected and articular index values are reduced by a course of iodobromine baths. A correlation was observed between the reduction of inflammation activity and the duration of morning stiffness. The most statistically significant alteration of the discussed parameters was found in patients with mild inflamma-

in Patients with Rheumatoid Arthritis under the Influence of Various Kinds

Biogenic amine levels					
DOPA		Serotonin		Histamine	
Before	After	Before	After	Before	After
24.9±1.1	24.2±0.9	15.4±0.21	10.3±2.89	21.1±1.0	12.3±1.1
27.4±0.86	30.0±1.2	13.7±1.9	15.3±2.3	16.1±1.05	18.0±1.0
23.6±0.87	28.4±0.9	17.2±0.76	16.1±3.7	19.4±0.8	11.3±0.41
25.3±1.1	23.1±0.87	16.4±2.3	11.4±2.23	18.2±1.1	12.4±0.8
24.5±0.67	28.4±0.65	14.6±2.44	16.9±1.21	19.6±0.8	24.8±0.3

tion. The natural question is what changes occur in the neurohumoral regulation and how they influence the clinical course of RA and AS. The answer lies in the assessment of iodobromine bath-induced alterations in the functional parameters of the major adaptive systems. To this end, the catecholamine response to therapy has been evaluated in patients with different activity of the disease.

Noradrenaline levels are increased and adrenaline levels are decreased by iodobromine baths. This suggests intensification of trophic and abatement of inflammatory processes, with greater changes in patients with moderate activity of the disease, as compared to those with mild activity. In patients with associated atherosclerotic cardiosclerosis, adrenaline levels were excessive (4.7 ± 0.12 μg/day); adrenaline secretion dropped to 3.3 ± 0.05 μg/day after therapy ($P < 0.01$).

Of no lesser interest are functional changes of the pituitary-adrenal and pituitary-thyroid systems induced by iodobromine baths.

Apart from the neuroreflex processes induced by iodobromine baths, experimental and clinical studies have demonstrated that both iodine and bromine enter the body. Iodine is absorbed mainly by thyroid cells, while bromine is absorbed by pituitary cells. Iodine is utilized by thyroid cells in tri-iodothyronine and thyroxine synthesis, whereas pituitary accumulation of bromine aids in ACTH and TTH functions of the anterior pituitary. This hypothesis is based on the findings of radioimmune studies of anterior pituitary and thyroid hormone levels in the blood. The iodobromine baths produced a 12.5

per cent increase in blood ACTH levels in all patients. The increase was especially prominent in persons (95.4 per cent) with low pretreatment ACTH levels.

Functional corticocyte activity was stimulated by the increased anterior pituitary ACTH function. As a result, total blood cortisol levels rose by 30.6 per cent.

Because of the elevation in TTH levels and entrance of iodine in the internal medium, blood tri-iodothyronine and thyroxine levels also increased. Activation of corticocyte function and cortisol release by iodobromine baths resulted in a lower cell permeability. inhibition of connective-tissue destruction, and immunosuppression. The alleviation of immune inflammation activated the function of thyroid cells, and tri-iodothyronine and thyroxine release into the blood was enhanced. The combined effect of these activities improved cellular metabolism and, especially, trophism of the synovial membrane, epiphyseal cartilage, and other affected joint components.

The cardiovascular system was also improved by iodobromine baths. Favourable changes were noted in left ventricular systolic phases in 75 per cent of patients with RA and 80 per cent of patients with AS. First of all, a reduction of the isometric contraction phase from the mean of 0.049 ± 0.002 sec to 0.047 ± 0.03 sec ($P < 0.05$) was observed. As a result, the phase of tension shortened from $0.109 \pm$ ± 0.002 to 0.108 ± 0.003 sec ($P < 0.05$). The expulsion phase, which was shorter than normal before therapy, was increased in 7.5 per cent of patients from 0.25 sec (normal is 0.245 sec) to 0.27 sec (normal is 0.246 sec), respectively. The myocardial tension index rose from 31.6 per cent to 32.4 per cent, and the cardiac index from 84.5 per cent to 85.8 per cent. Polycardiographic findings were impaired in 2.5 per cent of patients with AS. Perhaps the therapy was inadequate, since these patients suffered exacerbations of the disease. Evaluation of the effect of iodobromine baths on tissue blood flow indicated a decrease from 2.41 ± 0.17 ml/min/100 g tissue before therapy to 1.87 ml/min/100 g tissue after therapy. However, in some patients local tissue blood flow was increased, respectively, from 1.89 ± 0.2 to 1.99 ± 0.19 ml/min/100 g tissue. Probably, alteration of the central and peripheral haemodynamics by the baths facilitated the rapid penetration of xenon into the vascular bed. Similar findings were obtained after therapy with high or ultra-high frequency electromagnetic waves, either alone or combined with iodobromine baths. No response was obtained by administering a course of sham (blank) baths which fail to move xenon from the injection site.

Comprehensive clinical evaluation of the therapeutic effect of iodobromine baths on patients with RA and AS has shown them to be most effective in mild activity of RA and AS. In such cases therapy was ineffective or caused deterioration in 19.7 per cent. Patients with moderate activity of the disease showed significant exudative

and proliferative joint disorders, and their functional disturbances. Patients with mild disease received no drugs during bath therapy, whereas 55 per cent of patients with moderate activity of the disease were treated with drugs. Drug dosages were reduced or drugs were withdrawn in 45 per cent of patients.

A higher therapeutic efficacy was obtained by adding inductothermy to the therapeutic complex, especially in moderate inflammation activity. Major clinicolaboratory findings indicating inflammation activity were improved by such therapy. However, activation of AS occurred after the course of physical therapy, with its abatement upon follow-up examination. Patients treated with this therapy complex should be categorized as responders, since the activation of immune inflammation leads to higher macrophage digestion of collagen and metabolites accumulating in the synovial membrane and fibrous capsule because of scar tissue lysis. The clinical course is improved by such changes.

In connection with this, it was of interest to find out how the pituitary-adrenal and pituitary-thyroid functions are altered by therapy. A significant increase in blood ACTH and tri-iodothyronine levels was observed. Cortisol, thyroxine and thyrotropic hormone levels tended to improve. This therapy-associated dynamics suggests activation of the pituitary-adrenal and pituitary-thyroid systems, resulting in the alleviation of major clinical symptoms of RA (Fiveyskaya, Chepoy, 1971).

In addition, this therapy induced functional improvement of the sympatho-adrenal system (Vasilyeva, 1974).

Therapy decreased the activity of the hormonal and increased the activity of the sympathetic link of the sympatho-adrenal system, although noradrenaline levels did not reach average normal values.

Iodobromine bath therapy combined with inductothermy exerted a favourable influence on neuramine acid concentrations which were reduced to 72 ± 2.7 mg% by the iodobromine baths alone ($P < < 0.001$), and were even more greatly reduced (from 109 ± 5.1 to 78 ± 5.7 mg%) by the mentioned combination ($P < 0.001$).

Favourable ECG response was obtained by the combined use of iodobromine baths and inductothermy: myocardial reparation processes were activated, and tachycardia and tachyarrhythmia were diminished in one-fifth of patients. On the other hand, there was an ECG impairment in some patients with severe inflammation: *T*-wave amplitude was lowered, myocardial reparation processes were impeded, and heart arrhythmia recurred.

Notably, pretreatment tissue blood flow values were as low as 1.59 ± 0.20 ml/min/100 g tissue (bilaterally). After therapy with iodobromine baths and inductothermy, the values rose to $1.70 \pm \pm 0.15$ ml/min (1.68 ± 0.15 ml/min on the right, and 1.72 ± 0.30 ml/min on the left). The difference of the mean values equalled

0.11 ml/min/100 g tissue. A comparison of per cent differences of relative baseline values prior to and following therapy showed the mean increase of tissue blood flow to be 27.95±12 per cent (23.8±23.1 per cent on the right, and 32.1±23.5 per cent on the left). But no tissue blood flow enhancement was observed in patients who were treated with iodobromine baths alone. Thus, the mean pretreatment value was 2.41±0.17 ml/min (2.33±0.19 ml/min on the right, and 2.50±0.29 ml/min on the left), whereas after iodobromine baths it was 1.87±0.18 ml/min (1.85±0.26 ml/min on the right, and 1.89±0.25 ml/min on the left).

Apart from the effect of iodobromine baths and inductothermy, the dynamics of thermographic data revealing the absolute temperature at affected joint sites were assessed.

The vegetative nervous and vascular systems, as well as cellular metabolism, are best regulated by the concomitant application of iodobromine baths and inductothermy. Therefore, combined therapy of patients with RA and AS proves more effective than therapy using iodobromine baths alone.

By introducing inductothermy in the therapeutic complex consisting of iodobromine baths, exercises and massage, substantial therapeutic effect was obtained in 72 per cent of patients with moderate RA activity and 70 per cent of patients with AS, whereas the improvement rates in patients treated with the iodobromine baths alone were respectively 64 per cent and 54.3 per cent.

The above evidence shows that therapeutic effect of the iodobromine baths on patients with RA and AS is complicated. The baths induce non-specific and specific processes resulting in the regulation and restoration of the immunologic reactivity, enhancement of functioning of adaptive systems, depression of immunocompetent cell activity, trophic improvement in the synovia and other tissues (fibrous capsule, ligaments, etc.) of the joint, and amelioration of inflammation in the visceral organs (heart, lungs, kidneys, eyes).

However, in moderate activity of the discussed diseases, the pituitary-adrenal, pituitary-thyroid and sympatho-adrenal systems are functionally overstrained, and functional impairments and disease exacerbations are caused by the use of iodobromine baths alone. High and ultra-high frequency electromagnetic waves ought to be employed to promote adrenal blood supply, increase corticocyte number and function, and improve hormone synthesis.

These new scientific data will enable physicians to approach from an updated perspective the use of physical therapy, both locally and for different adaptive systems of the body. This will have pathogenetic effect on clinicomorphological and neurohumoral disorders in patients with RA, facilitating their working rehabilitation.

Pelloids and peat have an important place in therapy of patients with RA. World resources of fango and peat are enormous; it is

important that they be protected and rationally utilized for medicoprophylactic purposes. For rheumatoid arthritis, mud should be applied on a segmental reflex basis to the back-neck area, lumbosacral area, and to affected joints. Since the concept of high-temperature mud therapy as superior to low-temperature therapy still dominates, we have examined the effects of two mud temperatures, 38 °C and 44 °C. Except for the different temperatures of mud packs, identical therapy consisting of a clinical regimen, diet nutrition (diet No. 10), medical exercises and massage was prescribed for two groups of patients. In some patients, the general condition was improved and joint pain, morning stiffness and general weakness were ameliorated after as few as 5-6 procedures. The general condition improved gradually. However, 40.6 per cent of patients treated with 38 °C mud (complex 1) and 54.2 per cent of patients treated with 44 °C mud (complex 2) showed balneopathologic response or exacerbations after 5-6 procedures; these were malaise, intensification or onset of pain in the joints, increased joint oedema, longer morning stiffness and, in some patients, increased ESR. Mud packs were discontinued for 2-3 days in patients with severe response and reduced to 7-8 minutes in those with mild response. The well-being of patients was restored within 2-3 days, pathologic response and exacerbations did not recur, and the usual therapy was reinstituted.

The improvement in patients on 1 and 2 therapeutic complexes presented itself primarily as lesser joint pain during active/passive movements and on palpation. The articular index was reduced in 90 per cent of patients of the first, and in 80 per cent of the second group. Morning stiffness periods were reduced in 65.6 per cent of patients of the first, but in only 38.9 per cent of patients of the second group, whereas they became more prolonged in 6.3 per cent and 11.1 per cent, respectively. The duration of morning stiffness was unchanged in the remaining patients. Dynamometric results increased in 76.5 per cent of patients on complex 1 and remained unchanged in the remaining 23.5 per cent, whereas they improved in only 50 per cent of patients on complex 2, remained unchanged in 25 per cent, and even worsened in the rest. Alterations in inflammatory exudation may be assessed visually or by measured knee joint circumferences and sum circumferences of proximal interphalangeal hand joints before and after therapy. Knee joint circumferences were reduced in 66.6 per cent of patients on complex 1, and unchanged in 34.4 per cent. The reduction was seen in only 37.5 per cent of patients on complex 2; no change occurred in the same percentage of patients, and a slight increase of the measure was seen in 25 per cent of patients. Similar alterations occurred in sum circumferences of interphalangeal proximal hand joints: they were reduced in 71.4 per cent of patients of the first group; there was no change in 28.6 per cent of patients. In the second group, sum

circumferences of small joints of the hand were reduced in only 40 per cent; they were increased in 20 per cent, and remained unchanged in 20 per cent.

Thus, mud therapy resulted in the alleviation of the pain syndrome in both groups of patients. However, significant reduction of the articular index ($P < 0.001$) and duration of morning stiffness ($P < 0.05$) occurred only in patients receiving 38 °C mud packs; mean dynamometric values tended to increase in this group, whereas a contrary trend was observed in patients treated with 44 °C mud packs.

Simultaneously with pain and exudation reduction, an increase of the articular range was observed in patients of both groups: they could make a fist, lie with fully extended knees, walk upstairs and downstairs. The patients reported to have a 'free' soft sensation when walking, especially after mud pack.

Clinical studies on the efficacy of mud therapy in the two groups of patients demonstrated certain differences associated with the temperatures of mud packs. In patients of the first group, pain in the joints, morning stiffness, joint and periarticular exudative disorders were diminished, and muscular strength and articular range were increased. This response was far less manifest in patients of the second group, and was absent in some of them. Therefore, mud packs at 38 °C had greater anti-inflammatory effect. Because of functional activation of the adaptive systems, inflammation activity is depressed and its biochemical haematologic signs are ameliorated during the second half of the mud therapy course. This process seems to be prolonged, for there were no significant differences between pre- and posttreatment activity indices; however, the differences were revealed by comparison of the findings obtained in the middle, and at the end of therapy course.

Differences in therapeutic results in the two groups of patients were also seen in terms of immunologic parameters. Seropositive patients, i.e. those with higher pretreatment RF titres, comprised 60.6 per cent of the first, and 44.4 per cent of the second group; after mud therapy it decreased to 42.4 per cent in the first group and increased to 55.3 per cent in the second. Similar alterations were observed in IgA and IgG blood levels. There was no significant change in lysozyme levels in the two groups. However, pretreatment IgA and IgG levels considerably exceeded normal values in patients of the first group, whereas posttreatment levels tended to decrease. Similar alterations were seen with RF. Patients of the second group whose pretreatment values were similar to the above tended to have increased IgA, IgG, and RF levels after therapy. Although no marked changes in the immunologic reactivity were produced by mud therapy, the alteration of immune complex-contained IgA, IgG, and RF as well as lysozyme (lysosomal enzyme) in patients of the second

group indicated inflammation activation in these patients. Therefore, the immune response was consistent with the above-mentioned clinical and biochemical signs of activity of the disease in the two groups of patients.

The therapy-associated clinical alterations (shorter spells of morning stiffness, better general condition and alleviation of inflammation in the joints), in our opinion, were determined by the change of functional activity of the adrenal cortex and sympatho-adrenal system.

Blood levels of 11-oxycorticoids rose in 55.6 per cent of patients of the first, and in only 33.3 per cent of patients of the second group. They were found to decrease in 33.3 per cent and 66.7 per cent of patients, respectively. The levels of 11-oxycorticoids did not change in 13.6 per cent of patients of the first group. Enhanced urinary noradrenaline excretion was observed in a greater proportion (54.6 per cent) of patients of the first group, as compared with those of the second (43.8 per cent). Similar alterations were found in daily urinary adrenaline excretion. Such an 11-oxycorticoid response might be related to the fact that 44 °C mud packs, acting as an excessive stimulus for the articular inflammation focus, promote the inflammation and cause the overstrain of the adaptive systems, resulting in impairment of the systems instead of expected activation of adrenocortical glucocorticoid function. The increase in 11-oxycorticoid levels was statistically significant only in patients of the first group. These patients were found to have enhanced daily urinary catecholamine excretion. In contrast, no significant changes in total plasma 11-oxycorticoid levels and daily urinary catecholamine excretion occurred in patients of the second group.

In addition, the levels of 11-oxycorticoids, adrenaline and noradrenaline showed a correlation which remained after therapy.

Resistance to harmful agents is known to be determined by the activity of glucocorticoids and catecholamines; for this reason they are defined as adaptation hormones.

According to Orbeli (1939), the influence of the sympatho-adrenal system enhances the excitability of effector organs. The role of glucocorticoids is that by activating the energetic and metabolic balance of an effector cell, they enable it to respond to sympatho-adrenal impulses (the so-called permissive effect). Therefore, the hormones of the adrenal medulla initiate the response of the organism to a stimulus (in our case, mud packs of different temperatures). Adrenocortical hormones, the release of which is increased under these conditions, maintain the increased responsiveness of the effector cells, simultaneously exerting the anti-inflammatory effect. This is the reason for the correlation between the levels of the two groups of hormones.

Apart from clinical and laboratory tests, biopsies of the knee

joint synovial membrane were performed after mud therapy. The incidence of morphological signs and the volume proportions of tissue abnormalities in the synovial membrane of patients with mild RA after mud therapy are represented in Table 19.

The morphological study revealed a number of structural and metabolic features in the synovial membrane after the application of mud packs. All biopsy specimens showed chronic synovitis, except for 2 cases (one in each group) in which the structure of hyperplastic and sclerosed villi did not differ from that observed before

Table 19. Quantitative Characteristics (vol %) of Tissue Alterations after a Course of Mud Therapy in Patients with Mild Rheumatoid Arthritis

Tissue alterations	Posttreatment findings			
	Group 1	P	Group 2	P
Synoviocyte layer (μm)	8.3±1.8	0.05	8.5±0.9	0.05
Fibrinous deposits	—		—	
Hyaline deposits	2.8±2.2	0.05	0.9±0.9	0.05
Vasculitis, capillaritis	1.0±0.3	0.05	0.8±0.7	0.05
Vessels	17.1±1.3	0.05	19.8±1.8	0.05
Cell infiltrate	22.9±3.6	0.05	17.6±1.9	0.05
Fibrinoid changes	—		—	
Loose connective tissue	21.8±2.6	0.001	24.4±4.5	0.001
Sclerosis	26.0±3.8	0.02	28.2±4.6	0.02
Hyalinosis	2.8±3.2	0.05	0.9±0.9	0.05
Lipomatosis	6.6±2.3	0.05	8.3±2.5	0.05

therapy: the villi were lined with small cube-shaped or elongated cells with slightly pyroninophilic cytoplasm showing a low activity of redox enzymes and acid phosphatase. The subsynovial layer was represented by the fibrous or adipose tissue, with fibrocytes prevailing in it. There were small numbers of capillaries, arterioles and venules, and the inflammatory infiltrate was scarce, made of solitary lymphocytes, plasma and mast cells. Acid phosphatase was observed in the cytoplasm of separate cells throughout the tissue. The endothelium of some of the intact capillaries showed a low reaction to alkaline phosphatase, i.e. sclerotic and atrophic processes and capillary depletion were predominant in the synovial membrane. Mucoid swelling with diffuse subsynovial metachromasia was consistently seen upon toluidine blue staining. This was related to the release of free glycosaminoglycans from proteoglycan complexes. The sclerosed tissue was porous, collagen fibres and bundles showed

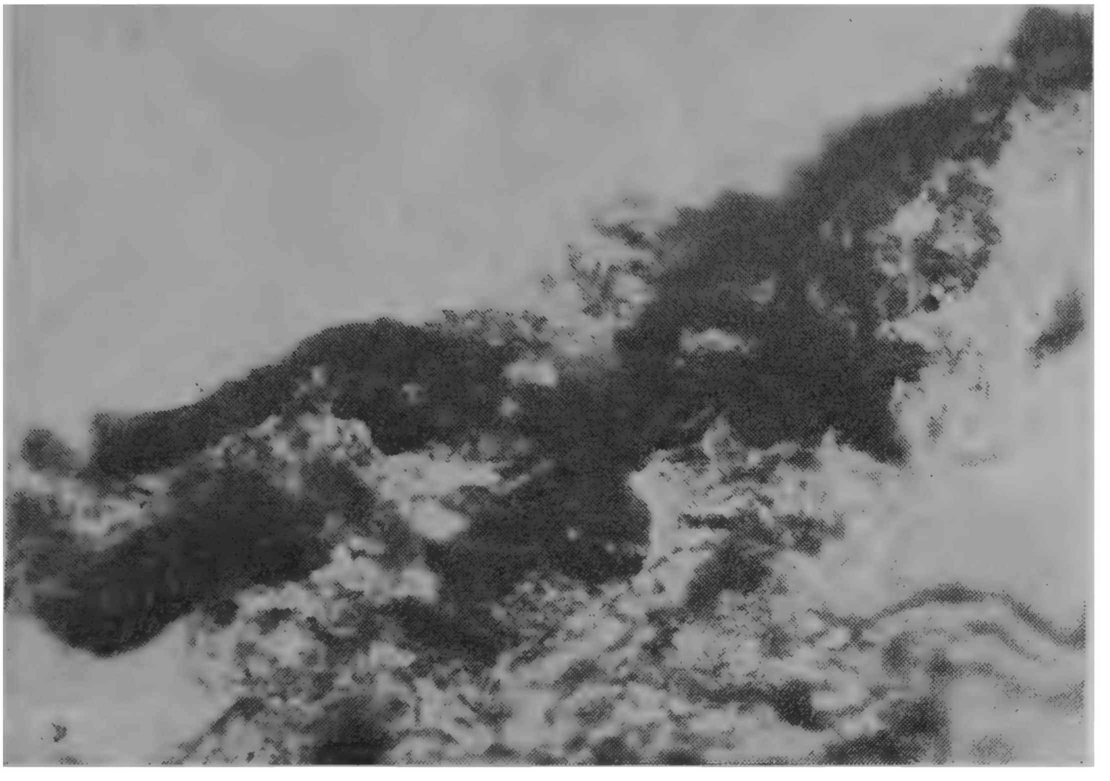


Fig. 27. Biopsy specimen of the synovial membrane of a 59-year-old female patient (before treatment). Mild rheumatoid synovitis. Positive acid phosphatase reaction in intact synoviocytes and solitary subsynovial macrophages. **α-naphthol test for acid phosphatase; × 140.**

swelling, picrinophilia, and partial lysis (Figs. 27, 28). There were increased numbers of microcirculatory vessels; in addition, structural and histochemical alterations were found in the vascular walls. The thickened capillary basement membrane was porous, and the endothelium was swollen (Fig. 29). The endothelium had greater numbers of alkaline phosphatase-positive capillaries. The sclerosed and thickened venule and arteriole walls were oedematous and slightly metachromatic upon toluidine blue staining; the endothelium was flattened in some vessels and succulent in others.

The histologically, histochemically and histoenzymochemically detected enhancement of vascular permeability during mud therapy was compatible with the clinical findings (no significant diminution of joint circumferences).

The most characteristic feature was the increase in the number of fibroblasts which comprised the greatest proportion of cells (three-fourths). A significant ribonucleoprotein content and moderate activity of redox enzymes and acid phosphatase were histochemically found in fibroblasts, suggesting their increased reproduction and

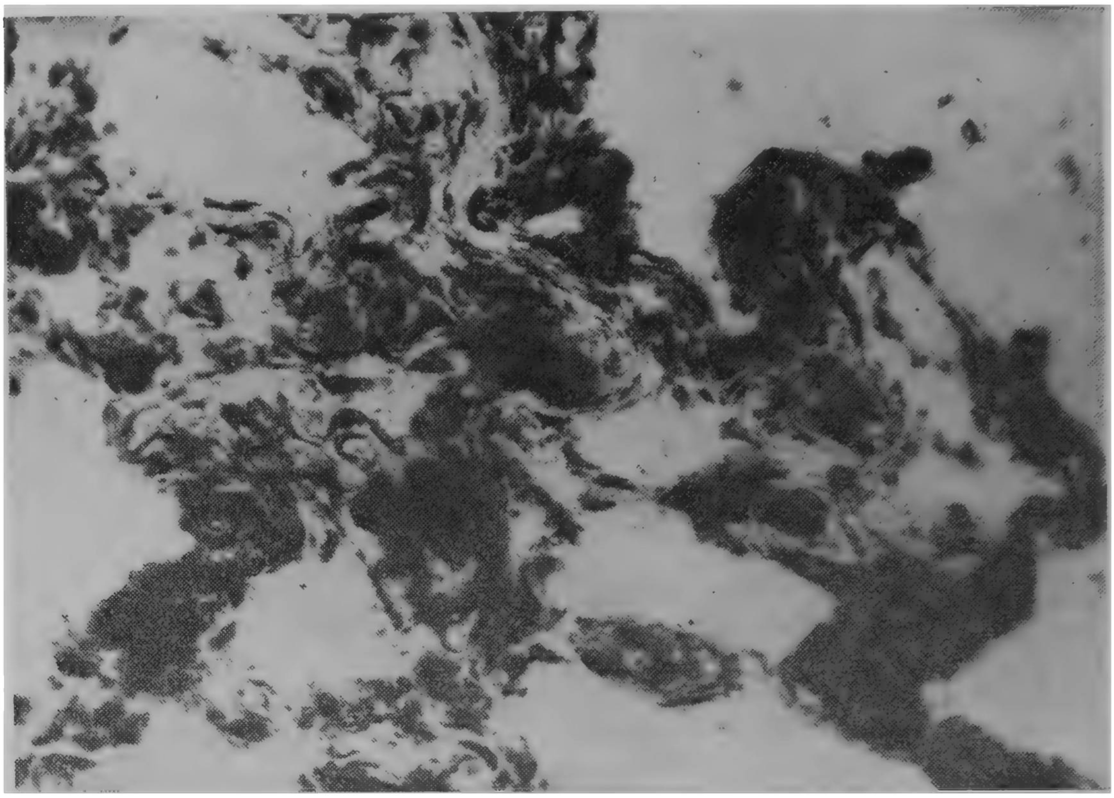


Fig. 28. Biopsy specimen of the synovial membrane of a 36-year-old female patient (before treatment). Mild rheumatoid synovitis. Moderate activity of NAD-diaphorase in synoviocytes, subintimal histiocytes, and capillary endothelium. NAD-diaphorase test; × 140.

clastic function. Inflammatory infiltration in sclerosed villi was mild manifested as solitary lymphocytes and macrophages. It showed no significant increase relative to pretreatment infiltration.

The measurement of thickness of the synovial layer showed it to be unchanged by mud therapy, but structural and metabolic changes were noted in synoviocytes. Although elongated fibroblast-like synoviocytes with slightly pyroninophilic cytoplasm showing low activity of redox enzymes and acid phosphatase were as previously recognized over much of the villous surface, one-sixth of the surface had sparsely located cube-shaped synoviocytes with markedly pyroninophilic cytoplasm with a high activity of redox enzymes and acid phosphatase.

A different pattern of therapy-associated changes in hyperplastic synovial villi was observed in mild inflammation activity. In a number of cases, scanty dense fibrinous deposits were seen on the villous surfaces; there were areas of synoviocyte proliferation, the synoviocytes being cylindrical, sparse, and arranged in 5-6 layers (Fig. 30). The synoviocyte cytoplasm showed pyroninophilia and high activity of redox enzymes and acid phosphatase. Toluidine

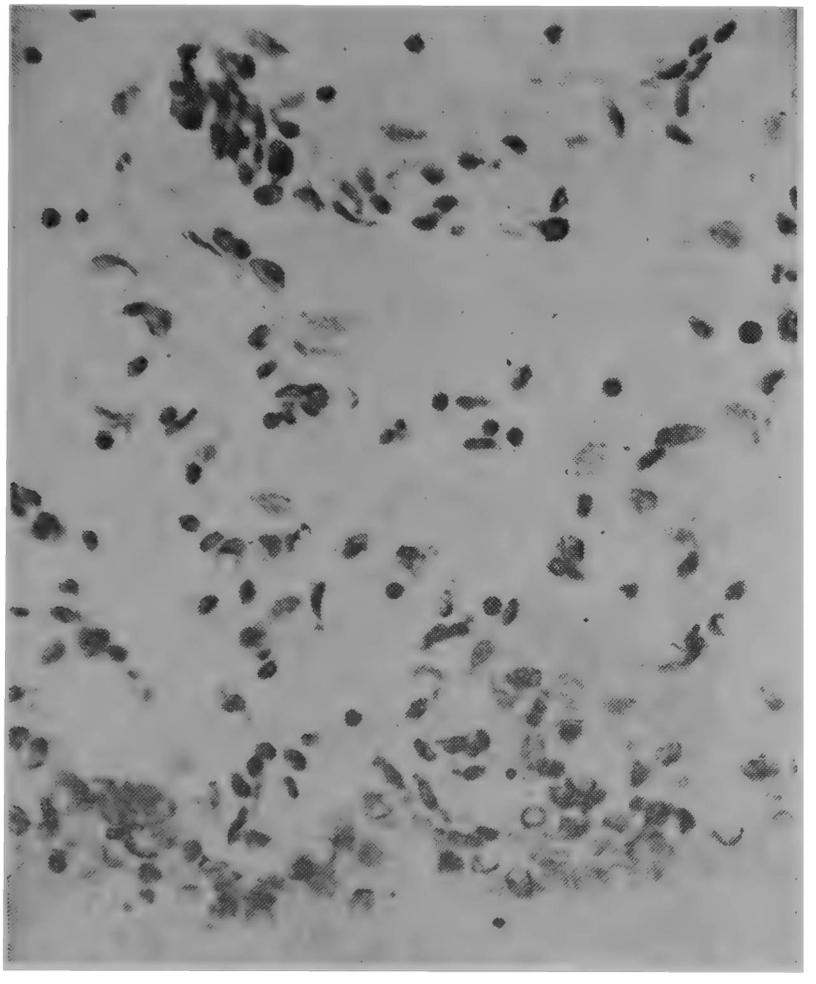


Fig. 29. Biopsy of the synovial membrane of a 43-year-old female patient (after therapy with 38 °C mud packs). Mild rheumatoid synovitis. Moderate cytoplasmic pyroninophilia in proliferating synoviocytes; plasma cells in the infiltrate, swollen endothelium in the capillaries and venules. Brachet's test; × 400.

blue staining revealed metachromatic granules (hyaluronic acid) in individual cells.

Inflammation of single capillaries was found in some RA patients. The inflammatory infiltrate remained to be perivascularly located, but its severity was greater. The predominant cells were lymphocytes and macrophages. Small proportions of polymorphonuclears, absent before therapy, were constantly observed.

Since patients with severe sclerotic articular changes were given 44 °C mud packs, sclerosed villi were predominant in biopsy specimens of the synovial membrane. The regression signs were fibroplastic activation, significant increase in the volume density of microcirculatory vessels ($P < 0.05$), porosity of the intermediate tissue ($P < 0.001$) with mucoid swelling and picrinophilia of collagen fibres. The inflammatory infiltrate was scanty, made of solitary lymphocytes, macrophages, and mast cells.

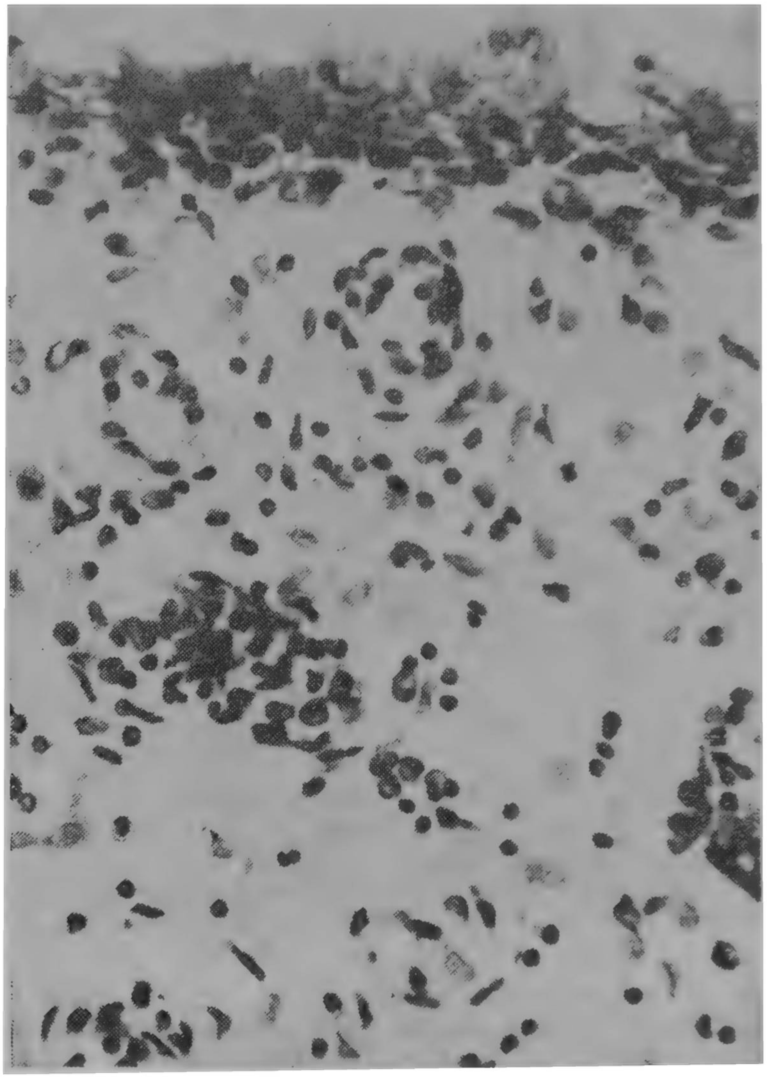


Fig. 30. Biopsy specimen of the synovial membrane of a 43-year-old patient (after therapy with 44 °C mud packs). Mild rheumatoid synovitis. Synoviocyte proliferation, with 4-5 cell layers formed, capillaritis, venulitis. Mild diffuse polymorphonuclear, lymphocyte and plasmocyte infiltration. Loose subintimal tissue, with activated fibroblasts predominant in it. Haematoxylin and eosin stain; × 400.

Like in patients with mild RA, no significant changes in immunologic parameters were noted after therapy.

An increase in total 11-oxycorticoid plasma levels was found in patients of both groups, with the proportion of patients with elevated 11-oxycorticoid levels greater (74.7 per cent) in the second group as compared with the first (62.5 per cent).

Enhancement of daily urinary adrenaline excretion was registered in a greater number (52.1 per cent) of patients of the second group, the proportion being 40 per cent in the first group. It was unchanged in the remaining patients.

The efficacy of therapy was evaluated on the basis of clinical and laboratory findings. There was an improvement in 66.7 per cent of patients of the first, and 88 per cent of patients of the second group. At the end of treatment no change in the general condition was noted in 23.8 per cent of patients of the first, and 8 per cent of patients of the second group; exacerbations occurred in 9.5 per cent and 4 per cent, respectively. Therefore, assessed in terms of per cents, the efficacy of therapy consisting of mud packs and inductothermy was greater in the second group of patients.

This conclusion is supported by the fact that by the end of therapy dosages of anti-inflammatory nonsteroid drugs could be reduced by 50 per cent in 62.5 per cent of patients.

Apart from the clinicobiochemical tests, histologic, histochemical and histoenzymochemical examinations of biopsy specimens of

Table 20. Ratios of Tissue Structures (vol %) in Two Groups of Patients with Moderate Rheumatoid Arthritis after Therapy (means ± SD)

Tissue alterations	Study period				
	Before therapy	Group 1	P	Group 2	P
Synoviocyte layer (μm)	10.1±0.6	9.9±1.0	0.05	8.3±0.8	0.05
Fibrinous deposits	4.1±1.0	1.8±0.06	0.05	1.1±0.7	0.05
Hyaline deposits	0.3±0.3	—	—	0.7±0.8	0.05
Vasculitis	4.6±1.1	3.4±0.8	0.05	1.4±0.6	0.05
Vessels	21.4±1.7	22.3±1.8	0.05	19.5±1.3	0.05
Cell infiltrate	34.4±2.8	29.0±1.9	0.05	27.8±1.0	0.05
Fibrinoid changes	1.8±0.1	1.6±1.0	0.05	—	—
Loose connective tissue	5.4±0.6	19.1±3.4	0.01	18.3±2.7	0.01
Sclerosis	19.1±2.7	13.0±1.0	0.05	19.6±2.0	0.05
Hyalinosis	1.2±0.1	4.0±1.2	0.05	4.0±1.2	0.05
Lipomatosis	8.0±3.2	5.8±1.5	0.05	7.6±1.2	0.05

knee joint synovial membranes were made in both groups of patients after therapy. The incidence of morphological disorders and alterations in volume proportions of tissue structures in patients with moderately active RA after mud therapy and combined use of mud packs and inductothermy are represented in Table 20.

Chronic, predominantly proliferative, synovitis was seen in all biopsy specimens. Morphological signs of regression are presented below (Fig. 31). The subsynovial layer was represented by fibrotic granulation tissue (Fig. 32).

Simultaneously there was a series of morphological features characteristic of the prescribed treatment. Biopsy specimens of the synovial membrane obtained from patients with moderately active

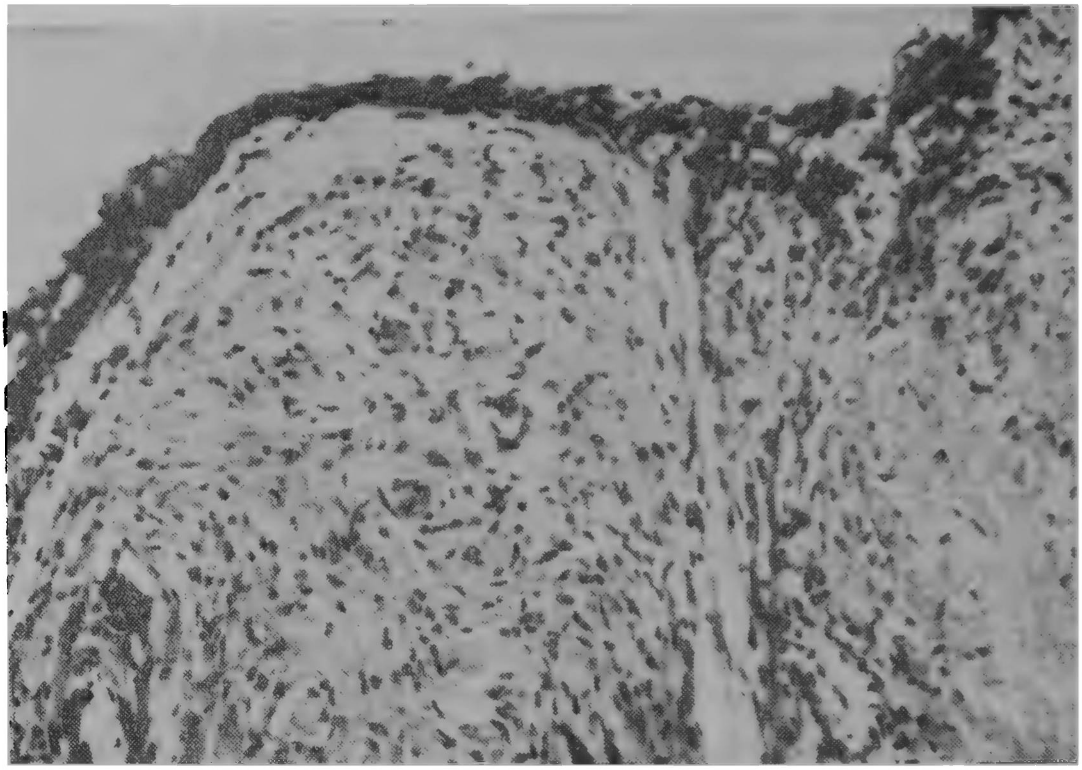


Fig. 31. Biopsy specimen of the synovial membrane of a 59-year-old female patient (after therapy with 38 °C mud packs and inductothermy). Moderate rheumatoid synovitis. Villous sclerosis. Focal synoviocyte proliferation, prevalence of fibroblasts, loose collagen bundles, succulent capillary endothelium. Haematoxylin and eosin stain; × 125.

RA after mud therapy showed suppressed immunopathologic response and concomitant marked resorption of the sclerosed connective tissue. Subsynovial arterioles and venules had porous walls and succulent endothelium. The endothelium of capillaries showed proliferation and high activity of acid phosphatase. The predominant cells were fibroblasts with pyroninophilic cytoplasm which had highly active redox enzymes, in particular NADP-diaphorase. Some cells were acid phosphatase-positive. The inflammatory infiltrate was small, perivascular and was made of lymphocytes, macrophages, plasmocytes, and had a proportion of polymorphonuclears; the infiltrate tended to resolve. There were solitary mast cells in the specimens.

Patients who did not benefit from the therapy experienced active inflammation. Severely hyperplastic villi showed proliferation of cylinder-shaped synoviocytes which locally made up 10-12 layers of palisade like arranged cells. The cytoplasm of synoviocytes was markedly pyroninophilic in the Brachet test. It had a high activity of redox enzymes and acid phosphatase. Polymorphonuclear exostosis of the synovial layer was seen in one case, and porous fibrinous deposits on the villous surface in another. The subsynovial layer

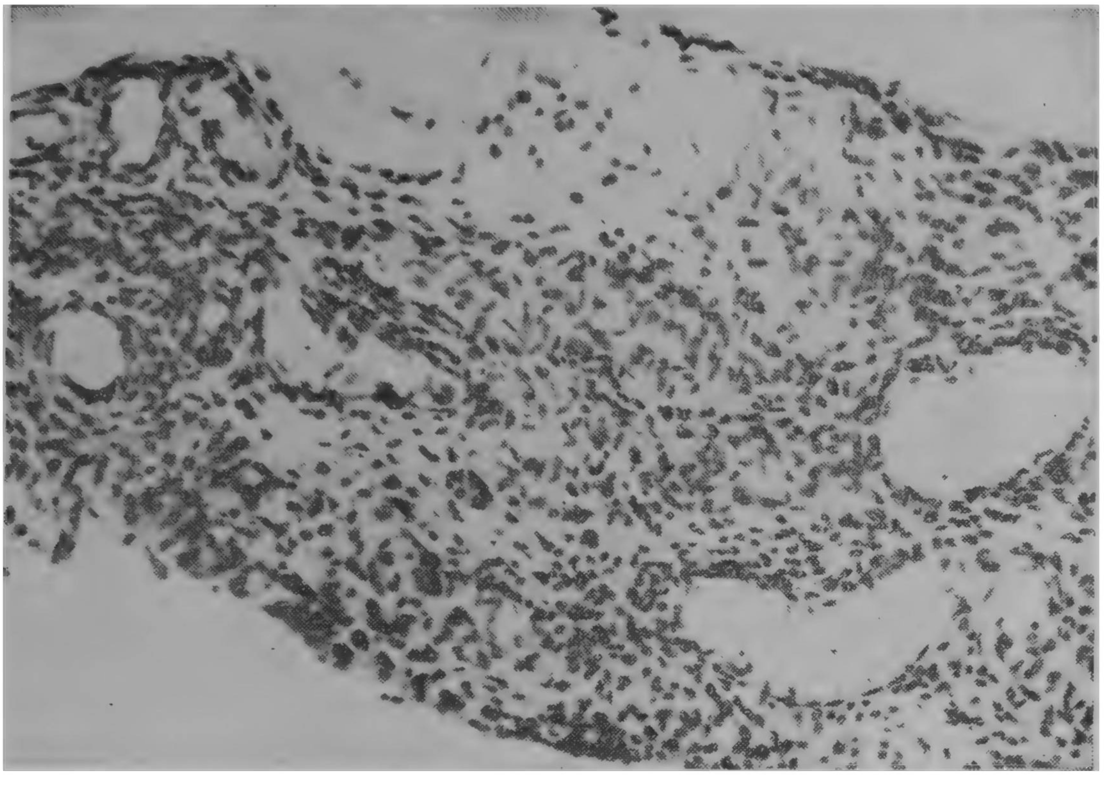


Fig. 32. Biopsy specimen of the synovial membrane of a 50-year-old female patient (after therapy with 38 °C mud packs). Moderate rheumatoid synovitis. A hyperplastic villus: organized fibrin masses over the surfaces of proliferating synoviocytes, focal lymphocyte infiltration. Sclerosing granulation tissue. **Haematoxylin and eosin stain; × 125.**

consisted of young granulation tissue, rich in lamella-formed cells with a high cytoplasmic activity of acid phosphatase and thin-walled vessels having succulent endothelium. There were focal fibrinoid, plasma leaks, capillaritis, and, occasionally, productive vasculitis. A high alkaline phosphatase activity was seen in the capillary endothelium. The volume of the inflammatory infiltrate did not differ from the pretreatment one; the infiltrate was diffuse in some places, perivascular in others, and was comprised of lymphocytes, macrophages, and plasma cells. The mast cells were actually absent, probably because of degranulation.

A significant abatement of inflammation was observed in a number of the synovial membrane biopsy specimens of patients who were given combined treatment (mud packs and inductothermy). All of the examined villi were sclerotic, and the volume percentage of sclerotic sites was not lower than the pretreatment one. Over a considerable portion of the villous surface, there were fibroblast-like synoviocytes with slightly pyroninophilic cytoplasm showing a low activity of redox enzymes and acid phosphatase; on the other hand, small foci of synoviocyte proliferation were seen, with a 4-5-layer arrangement of small cells. An outgrowth of fibrous connective

tissue rich in fibrocytes and fibroblasts was observed in the subsynovial layer. The cytoplasm of fibroblasts was pyroninophilic and acid phosphatase-positive (Fig. 33). Van Gieson's stain showed fuchsinophilia of the collagen bundles. The intermediate tissue was orthochromatic upon toluidine blue staining, although there were metachromatic sites. Solitary lymphocyte and macrophage inflammatory infiltration was scarce and perivascularly located (Fig. 34). Polymorphonuclear cells were absent. In all of these cases, there was an improvement in the clinical picture of the articular disease and the laboratory tests. Upon hospital discharge, 2nd degree local inflammation activity changed to 1st degree activity.

In addition to sclerotic changes in some of the biopsy specimens there were persistent sites of active inflammation, being manifested as focal synoviocyte proliferation and inflammatory cell infiltration, both diffuse and focal, in the form of lymphoid follicles. Small polymorphonuclear admixtures were seen in the infiltrate. The subsynovial layer had numerous fibroblasts, some of which were positive to acid phosphatase, and the intermediate tissue had considerable number of mast cells. The clinical improvement was significant in

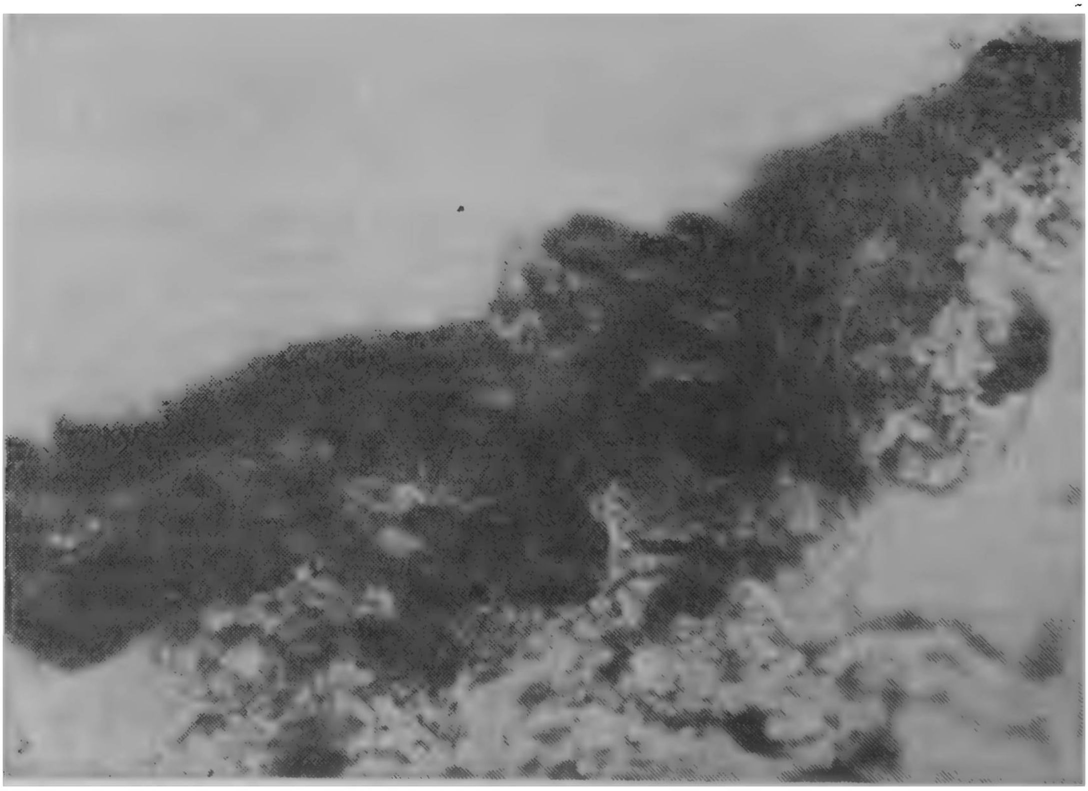


Fig. 33. Biopsy specimen of the synovial membrane of a 36 year-old female patient (after therapy with 38 °C mud packs). Rheumatoid synovitis of moderate activity. Highly active acid phosphatase in synoviocytes and subsynovial macrophages. Azodye—α naphthol test for acid phosphatase; × 140.

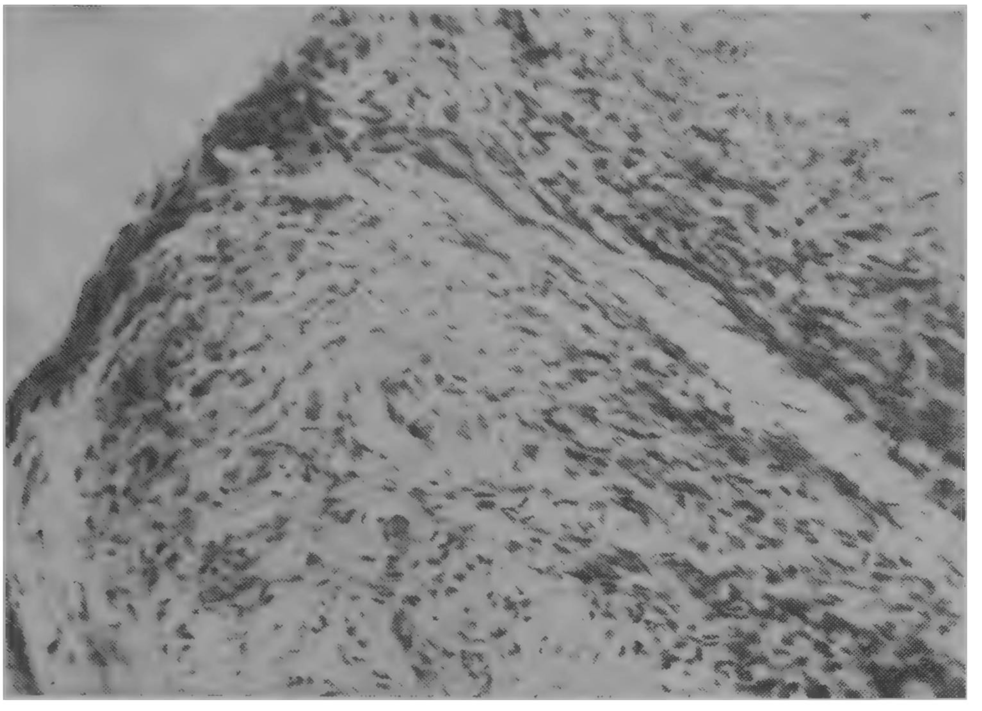


Fig. 34. Biopsy specimen of the synovial membrane of a 59-year-old female patient (after mud packs and inductothermy). Moderate rheumatoid synovitis. A sclerosed villus: proliferation of synoviocytes making up 4-5 layers, loose subsynovial layer. Mild lymphoid infiltration. Haematoxylin and eosin stain; × 125.

these patients, and the inflammation activity of the 2nd degree was retained upon hospital discharge.

The immunofluorescence study of the biopsy specimens showed fluorescence of IgG, IgM and complement-reactive groups in the vascular walls and extracellularly.

Thus, mud therapy for moderately active RA suppresses the immunopathologic response of the synovial membrane: there is a tendency of reduction in the volume proportion of lymphocyte, macrophage and plasmocyte infiltration ($P > 0.05$), and the incidence of vasculitis is reduced ($P < 0.05$). Like in minimally active RA, fibrinous deposits promote collagenolysis which is characterized by porosity of the intermediate tissue ($P > 0.01$), focal mucoid swelling and picrinophilia of the collagen fibres, increased permeability of the capillary wall, availability of macrophages and polymorphonuclear cells in the perivascular infiltrate, and significant number of fibroblasts (Fig. 35).

The synovial morphological changes are different when mud therapy is used in combination with inductothermy. Compared to patients treated with mud packs alone, the suppression of the immunopathologic process is greater in these patients. It is characterized by a stromg diminution of the inflammatory cell infiltrate ($P <$

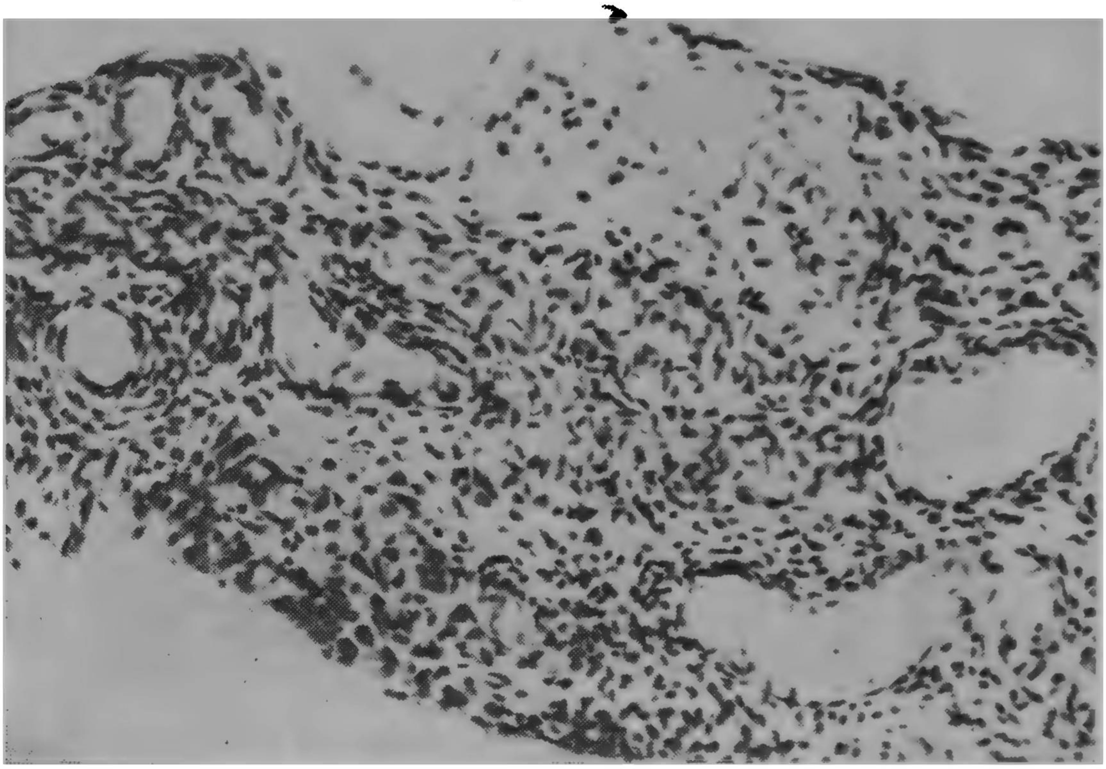


Fig. 35. Biopsy specimen of the synovial membrane of a 35-year-old patient (after therapy with 38 °C mud packs). Moderate rheumatoid synovitis. **Villous hyperplasia, strong dilation of venules and lymph spaces.** Diffuse infiltration **with lymphocytes and single polymorphonuclear cells. Great numbers of fibroblasts with succulent cytoplasm.** Haematoxylin and eosin; × 125

< 0.05), depletion of capillaries, sclerosis of the walls of intact vessels, and a lower fibroplastic response. However, the statistically significant increase in the volume proportion of the loose connective tissue, revealed by histostereometry, also indicated the regression of sclerotic changes in the affected joints. Yet the resorption of sclerosis was less in this therapy and seemed to occur primarily through fibroclasia which was morphologically manifest as high activity of acid phosphatase in fibroblasts.

Therefore, the morphologically revealed changes in the synovial membrane were the basis of the effect of mud therapy, or mud therapy and inductothermy, as seen by clinical and laboratory criteria. The anti-inflammatory effect of the therapeutic complexes was verified both clinically and morphologically in both groups of patients.

The regression of sclerosis in patients of the second group was greater than that in patients of the first group due to the fibroclasia-activating effect of the mud and high-frequency electromagnetic waves. As observed clinically, mud packs alone produced inadequate anti-inflammatory effect. There was no significant activation of adaptive functions. The morphologically prevalent process was

resorption of sclerotic sites, occurring both intracellularly due to fibroclasts and extracellularly due to collagenase and lysosomal enzymes of cells of the inflammatory infiltrate.

The much higher anti-inflammatory effect of the therapeutic complex employing inductothermy was also manifested as a lower incidence of balneopathologic responses and exacerbations.

In addition to examination of the synovial membrane, cytochemical and immunofluorescence studies of the synovial fluid were performed after therapy. The clinical, biochemical and immunological studies revealed an improvement in articular abnormalities. Cytologic examinations of the synovial fluid after mud therapy showed no significant changes relative to the pretreatment data. The indices of cytosis (23 000-31 000/μm) and rhagocytosis (64-80 per cent) remained high; synoviocytograms showed prevalence of neutrophils (71-75 per cent). Percentages of cells displaying high activity of acid phosphatase were not altered, either. Lymphocytes were represented primarily by T and null cells, while B-lymphocyte counts remained low. The highest values of cytosis (31 000) and rhagocytosis (87 per cent) were found in patients with exacerbations of the disease. An improvement was seen in patients of the second group: cytosis in the synovial fluid obtained after therapy was reduced to 15 000/μm, and rhagocytosis to 47 per cent; the neutrophil proportion in the synoviocytogram was reduced to 71 per cent, whereas the proportion of lymphocytes was increased. Also, there was a change in T- and B-lymphocyte proportions, the latter being increased by about 10 per cent. The results of pre- and posttreatment examination of the synovial fluid of patient L. treated with mud and inductothermy are represented in Fig. 36.

In conclusion, the studies have demonstrated that patients with RA of moderate activity tolerated well 38 °C mud packs concurrent with drug therapy and the therapeutic complex using mud packs and inductothermy. Mud therapy combined with inductothermy was found to be more effective. It enabled the reduction of drug dosages and, in some cases, their withdrawal by the end of mud/physical therapy or somewhat later.

Combined therapy consisting of 38 °C mud packs resulted in a significant improvement of the general condition, joints and biochemical blood tests of patients with stage I of the disease and 90 per cent of patients with stages II and III of the disease: secondary synovitis, leukocytosis and ESR were diminished, and C-reactive protein tests were negative.

Evaluation of the sympatho-adrenal system showed a considerable improvement of its function in all patients, regardless of the disease stage. The tone and reactivity of the sympathetic nervous system, functional activity of the hormonal and mediator links of the sympatho-adrenal system, trophic processes in the walls of great ves-

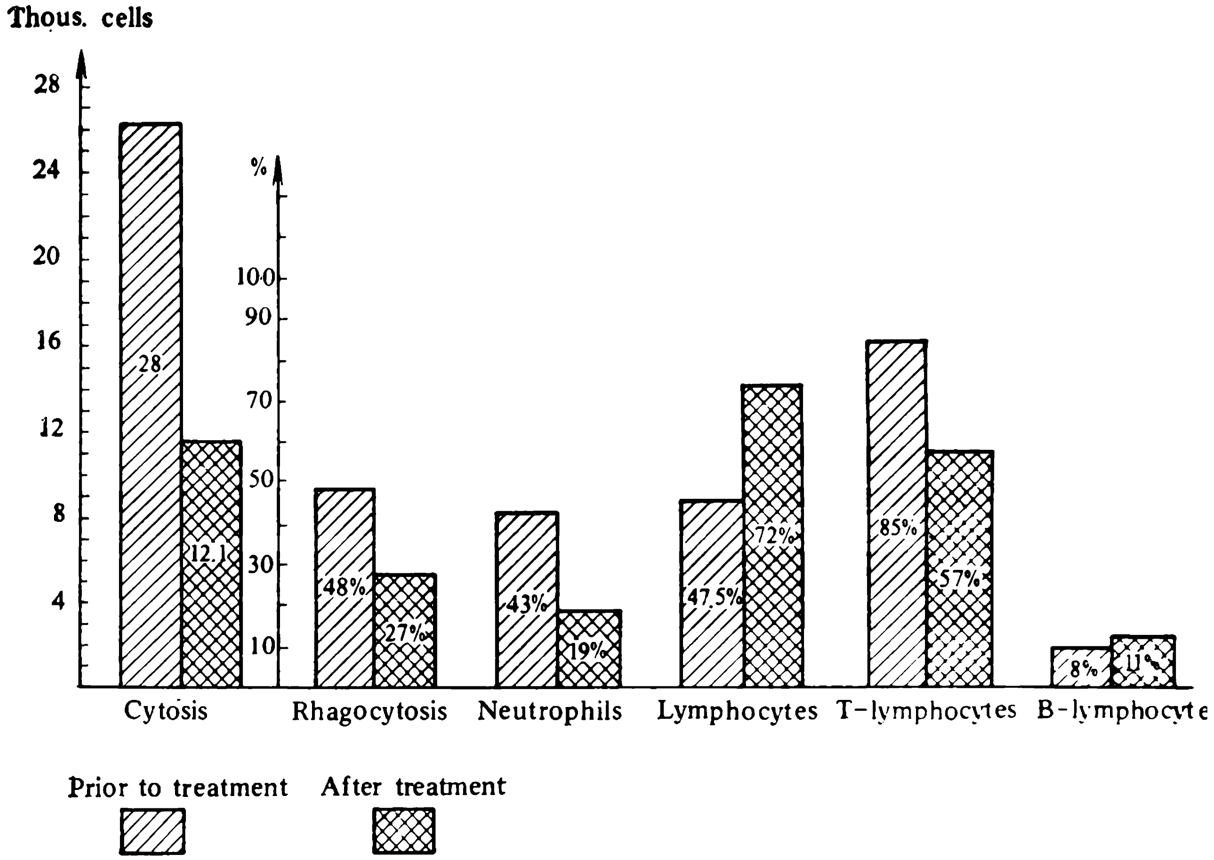


Fig. 36. Alteration of synovial fluid by mud therapy and inductothermy in patients with rheumatoid arthritis of moderate activity.

sels, including synovial ones, were enhanced by 38 °C mud packs.

Findings of rheographic tests of the great vessels of the extremities in patients with stage I of the disease suggested a greater vascular blood-filling at sites of the affected joints. It was indicated by an increase in the rheographic index from 0.37 ± 0.002 to 0.04 ± 0.001 ($P < 0.05$) and the tendency of lower vascular wall tension.

Trophic effect of catecholamines on the synovial vessels was found to be still greater in patients with stages II and III of the disease.

Altogether, these changes showed that 38 °C mus packs improved elastic properties of the vessels, decreased vascular wall tension, and increased blood-filling at the tested sites.

There were a statistically significant decrease in serum hexose levels and a tendency of reduction in serum seromucoid levels. Mud packs cause elevation of activity of copper-containing cytoplasmic enzymes which participate in redox processes and metabolic activation of synoviocytes, chondrocytes, and connective-tissue cells.

Similar changes were noted in blood aluminium testing. This was indirect evidence of increased activity of aldolase, lactate dehydrogenase and alkaline phosphatase in the synoviocyte cytoplasm

and the endothelium of the blood-synovia barrier of the synovial membrane. Metabolic activity of cells, synoviocyte secretion, chondrocyte enzymic activity and chondrocyte regeneration were increased, whereas degeneration of the epiphyseal cartilage was decreased. There was a statistically significant reduction in serum nickel concentration which dropped far below normal. It might be related to therapy-associated activation of dehydrogenase, rapid synthesis of macroergic compounds in tissues, and intensification of redox processes in tissues, dehydrogenase being activated by nickel. A correlation was established between serum aluminium levels and catecholamine levels in 24-hour urine.

The discussed therapeutic complex caused a statistically significant decrease in serum cobalt concentration in patients with any stage of the disease. It was probably due to mud pack-induced activation of enzymes which are indirectly (not specifically) influenced by cobalt: succinate dehydrogenase and cytochrome oxidase, i.e. enzymes involved in oxidation processes of the synovial medium. A statistically significant elevation of serum levels of silicon in patients was determined by its uptake from silicon-containing compounds in the mud or by the systemic release of silicon from the body stores. Availability of these 'formative' substances in the synovial tissues is enhanced by activation of the synovial metabolism, resulting in greater synthesis of protein-polysaccharide compounds of collagen and intermediate substance of the synovial and cartilaginous connective tissue.

It should be mentioned that 70 per cent of patients developed balneopathologic response after 5-6 procedures: the general condition and pain in the joints worsened. However, a 1-2-day withdrawal of mud therapy rather than the institution of drug therapy is required during this period; a marked clinical response was eventually seen by the end of treatment.

According to clinical, electrophysiologic and biochemical findings the tone and reactivity of the sympathetic nervous system react inadequately to 44 °C mud packs. This was indicated by a lack of significant elevation in the levels of sympatho-adrenal mediators. It might be related to the impairment of adrenaline synthesis in the medulla due to the high temperature of the mud, on the one hand, and the inhibition of mediator release in sympathetic synapses, on the other. As a result, trophic effect of catecholamines on the cellular metabolism is impeded. Deficient in the sympathetic membranes, catecholamines fail to have a trophic influence on vessels of the extremities, including synovial ones. Redox processes in the vessels and tissues of the synovial membrane and epiphyseal cartilage are impaired, and there appear underoxidized metabolic products whose vasodilator properties are inadequate. It is partly for this reason that vasoconstriction and elevated 'basal' vascular

tone persist. Thus, trophism is impaired, and cells and the intercellular substance of the connective tissue and cartilage are destroyed. Furthermore, decomposition of protein-polysaccharide complexes and carbohydrate-containing polymers intensifies.

The therapy causes a reduction in excessive aluminium and an increase in manganese serum levels in patients with stage I of the disease. This is probably a result of the elevated activity of metal enzymes, the activity being dependent of aluminium ions—aldolase and lactate dehydrogenase. Furthermore, biosynthesis of protein-polysaccharide complexes in the basic substance of the synovial membrane connective tissue increased, while copper levels decreased and silicon levels increased in patients with stage I of the disease. These changes in the content of trace elements corresponded to a favourable clinical response.

Consistent elevated serum levels of copper and aluminium in patients with stages II and III after therapy indicate their adverse effect on the activity of copper- and aluminium-containing enzymes, i.e. lower metabolic activity of the synovial cellular constituents and deterioration of degeneration in the joints. This was corroborated by the correlation observed between elevation of serum hexose levels and serum copper and aluminium levels in patients with secondary synovitis (r_1 for hexose-copper was 0.5; r_2 for hexose-aluminium was 0.58), and by the correlation between the levels of trace elements and daily urinary excretion of oxyproline ($r_1 = 0.38$; $r_2 = -0.37$).

The synthesis of protein-polysaccharide complexes and collagen of the intercellular substance in the connective tissue remained low. This contributed to trophic impairment in the synovial membrane and cartilage, and to secondary synovitis.

The efficacy of therapy consisting of 44 °C mud packs was much lower, as indicated both clinically and biochemically.

Clinical examinations of patients who were treated with combined therapy comprising diet, therapeutic exercises, massage, 38 °C mud packs and decimetre-range electromagnetic waves delivered with 45-50 Wt Volna-2 device to spinal ganglia, corresponding to the affected articular segments, and to the affected joints revealed better general condition and sleep of patients. The combined therapy was well tolerated by patients. Mud packs and decimetre-wave therapy were interspaced with a 2-3-hour resting interval. Vegetative vascular disorders were alleviated in 80 per cent of patients. The vegetative response was aggravated by the 6th-7th procedure in 20 per cent of female patients with menopausal disorders. After a period of treatment withdrawal, therapy was resumed.

A clinical response was seen in 95 per cent of patients with stage II of the disease: pain was terminated in 62 per cent, it was aggravated only by exercise and weather change in 18 per cent, and was less

in 15 per cent of patients. Muscle turgor and skin elasticity were improved in all patients.

Rheographic findings indicate an enhancement of blood-filling and diminution of the vascular tone at the projection sites of degenerated joints. Pulse wave speed was reduced in stages II and III. These data suggest that redox processes are activated in the great vessels of extremities and the synovial vessels due to trophic effect of catecholamines on their metabolism. The increased oxygen absorption activates aerobic glycolysis and release of cellular metabolites which are potent vasodilators.

In sum, this therapeutic complex, acting on the central, myogenic and metabolic regulation of peripheral circulation, reduces the tone of the vascular wall, improves its elasticity, and enhances blood-filling in tissues of the joints.

The statistical significance of the effect of 38 °C mud packs and decimetre-wave therapy on the adaptive-trophic function of the sympathetic nervous system and electrolyte, lipid and calcium metabolism is greater than that of 44 °C mud packs. There is a statistically significant reduction in hexose levels and a tendency of the serum seromucoid level to decrease. This suggests a lower rate of decomposition of carbohydrate-containing polymers in the basic substance of the connective tissue, the polymers being a major link between glycosaminoglycans and hyaluronic acid. This ultimately implies a lower dissociation of protein-polysaccharide complexes in the connective tissue of the synovial membrane and cartilage and, consequently, reduced inflammatory exudation.

Analyses of serum trace elements revealed a statistically significant reduction in copper concentration in all stages of the degeneration process. This indicates an increased activity of cytoplasmic copper-containing enzymes which are involved in redox processes and metabolic activation of cells.

In contrast to 38 °C mud packs, this therapeutic complex does not alter serum nickel and cobalt concentrations. It confirms the abatement of the inflammatory exudation in this combined therapy and the resultant inactivity of enzymes which require nickel and cobalt to be activated.

The reduction of serum copper and aluminium levels in patients with any stage, the normal range of nickel and cobalt concentrations, the statistically significant reduction of serum hexose levels, and the tendency of seromucoid levels to decrease indicate marked efficacy of the mentioned therapeutic complex.

It should be noted that a much higher efficacy is obtained by combined therapy, especially in patients with inflammatory exudation. This therapy produces a greater increase in the tone and reactivity of the sympatho-adrenal system which ensures trophic improvement of the vascular tissue in the synovial medium and lower 'basal'

vascular tone. Tissue blood-filling is eventually increased since the therapy intensifies the function of the blood-synovia barrier of the articular capsule and the regulation of postcapillary microcirculation and transcapillary exchange, and enhances the metabolism of cells and the basic and intermediate substance of the connective tissue of the synovial membrane and cartilage.

Therefore, clinical and biochemical dynamics and therapeutic response testify to the therapeutic efficacy of 38 °C mud packs. The efficacy is much higher in combined use of 38 °C mud packs and ultra-high frequency decimetre-range electromagnetic waves.

It should be borne in mind that aseptic necrosis of bones that make up a joint should be strongly considered in articular disease so as to avoid diagnostic errors and balneotherapeutic risk.

Chapter 14. Osteochondropathy

What is termed osteochondropathy was singled out from numerous bone and joint diseases at the beginning of this century. The basis of this disease is aseptic necrosis of short and small bones, and epiphyses of long tubular bones which are exposed to greater mechanical strain due to their anatomic location.

The affection of bones primarily in childhood and adolescence is common for osteochondropathies of all locations. Local circulatory disorders result in necrosis of the spongy tissue of individual bones. Continual minor injury is believed to be the basis for the onset of bone necrosis. However, bone necrosis is not a result of purely mechanical obstruction of vessels due to minor injuries. Contributary factors are neurovascular and trophic disorders resulting in aseptic necrosis of the spongy substance of the bone. Osteochondropathies are typified by peculiar late-onset changes at the affected site: structural recovery of the bone occurs without sclerosis or marginal bone outgrowths, thickening of the articular cartilage and widening of the articular slit are observed. These are not seen in arthrosoarthritis.

Nowadays it has been demonstrated by X-rays that, contrary to a common view (Kreuter, Lang, Assmann), osteochondropathies result not in deforming arthritis or arthrosis but in structural recovery of deformed epiphyses.

In a number of West European countries, the discussed osteoarticular lesions are not defined as osteochondropathies; older terms like 'osteoarthritis', 'osteochondritis of the femoral head' are adhered to. These definitions should not be criticized, for these diseases occur not as inflammatory processes but as necrotic processes which, passing through a degenerative-productive stage, result in structural reparation of the deformed epiphysis. Study of pathomorphological changes and their elucidation in osteochondropathy became possible owing to the clinical introduction of the X-ray method. Reinberg and Rokhlin are right to state that the therapy of osteochondropathies arose thanks to roentgenology, and in fact, roentgenologists and

surgeons mastering the X-ray technique created this branch of medicine. In recent decades it has been established that patients with osteochondropathies can be treated not only in orthopaedic, traumatologic or physiotherapeutic institutions but also in sanatoria where balneologic and fango therapy may be used extensively.

14.1. Osteochondropathy of the Head of the Femur (Legg-Perthes-Calvé's Disease)

In 1910, surgeons Legg, Calvé and Perthes reported peculiar epiphyseal abnormalities of the head of the femur, thereby originating the theory of this disease. This is the most common of osteochondropathies. The disease occurs predominantly in childhood and adolescence, and its incidence in boys is 5-6 times higher than in girls. Its initial period is usually asymptomatic, and is followed by the abrupt onset of pain and lameness. Pain often irradiates to the knee joint, like in coxitis, and is greater after walking. As it has been correctly pointed out by Sitenko, its clinical course is milder than that of coxitis: there is no fever, suppuration, or ankylosis, and blood chemistry is usually normal. The only symptoms inducing the patient to consult a physician are limping and pain.

Restricted thighbone abduction and normal extension/flexion in the coxofemoral joint are observed clinically. The restricted thighbone abduction at the onset of disease is associated with adductor strain and later with deformity of the head of the femur. In some patients, there are abnormalities of the coxofemoral synovial membrane and infiltration and swelling of soft tissues around the joint, resembling initial tuberculous coxitis. However, in contrast to the latter, movements are painless in Perthes' disease, exercise causes no severe pain, and striking of the soles and greater trochanter does not hurt. Elevation of the greater trochanter due to partial resorption and flattening of the head of the femur is found on palpation. Apart from actually shortening the leg by a few centimetres, its functional shortening due to adduction contracture of the femur occurs. Musculus gluteus (middle and small) become hypotrophic. The Trendelenburg's test is positive. The disease continues for 6-7 years, resulting in the deformity of the femoral head.

It has been firmly established that underlying the pathologic abnormalities in osteochondropathies is primary aseptic subchondral epiphyseal necrosis which is followed by the complicated process of bone regeneration. A probable cause of the necrosis are vasomotor disorders associated with innervation disturbances. Such disorders may occur in superimposed minor injuries, especially because of the abnormal strain of joints.

According to Reinberg, vascular spasticity may not necessarily occur in osteochondropathies; the paretic status of the vessels may

lead to arterial hyperaemia with blood stasis and resultant complications. Therefore, Perthes' disease may be induced by factors causing epiphyseal malnutrition of the head of the femur.

Five stages of the disease are distinguished: the *first* stage is necrosis involving the spongy tissue of the femoral head and the bone marrow, with the chondral layer remaining intact; therefore, the disease occurs subchondrally. The destroyed bone tissue is regenerated by the adjacent normal bone, and necrotic fragments are resorbed and gradually replaced by newly-formed bone tissue. The metaphyseal portion of the periosteum is buried in the necrotic site where the cartilage is attached to the bone. Therefore, the necrotic osseous framework of the femoral head rapidly loses its mechanical properties; it cannot bear its usual load, and the *second* stage sets in, fracture due to compression. Relatively mild injuries produce microscopic fractures, driving bone trabeculae into each other. Because of extensive necrosis, macroscopic compression fractures appear, and the head of the femur is flattened down. At this time X-ray diagnosis can be made. Then there is the *third* stage of resorption. Bone splinters disappear, connective-tissue bands of the head of the femur get deep into the necrotic tissue, and the whole head is fragmented. Along with bone splinter resorption there occurs formation of new bone tissue. The *fourth* stage has begun: bone reparation. The bone is repaired as a result of metaplasia of connective-tissue and cartilage elements which grow into the epiphyseal portion of the femoral head from adjacent tissues. Cyst-like formations are observed in this stage; the necrotic osseous femoral epiphysis is replaced by hard spongy tissue. Osteochondropathy of the head of the femur finally proceeds to the *fifth* stage, in which secondary abnormalities associated with a specific deforming osteoarthrosis occur. Any inflammatory disorders of the femoral epiphysis are absent throughout the disease, only regenerative-reparative phenomena are seen after aseptic necrosis of the head of the femur.

In the opinion of Reinberg and other roentgenologists, a characteristic X-ray pattern appears as early as in the second stage of osteochondropathy. The head of the femur is evenly darkened, and has no structural pattern. Flattening of the head (a one-third or one-fourth reduction in its height) is of great diagnostic significance. The head is poorly outlined and uneven, the articular slit is widened because of an early reactive process in the articular cartilage (its proliferation leads to the thickening of its radiolucent portion). In the third stage, the head of the femur disintegrates into irregularly outlined fragments. This is the so-called sequestral pattern of osteochondropathy. The head of the femur is increasingly flattened, the articular slit is wider than in the second stage, and the femoral neck is shorter and thicker. The pain syndrome is greatest during this stage. Destruction and pain suggest specific tuberculosis, and

patients are not infrequently placed in a plaster cast. In the fourth stage, the spongy tissue reappears in X-rays at the epiphyseal portion of the head of the femur. Serial X-rays show smaller numbers of necrotic sites. Finally, in the fifth stage, the head of the femur has a normal structure, but it is very flattened, the femoral neck is short, the articular slit is wide, the acetabulum is somewhat elevated, the head of the femur being out of it. Subluxations are feasible, and coxa vara is usually seen.

However, this relatively mild course of the disease is not uniformly observed. We saw patients with Legg-Perthes-Calvé's disease to experience severe pain syndrome, impairment of static and motor function of the leg, and transient disability. Moderate locomotor disorders were common in our group of 77 patients with Perthes' disease. It was more severe in 25 patients who could not work for many months. The prolonged application of various physical factors was unsuccessful, and the patients were referred to resort institutions.

The following case history is presented as an example.

Patient I., 27 years old, was admitted to the Pirogov Surgery Sanatorium because of severe pain in his left hip joint. The patient suffered from severe lameness requiring the use of crutches. Eight years previously he began to have mild left-sided inguinal and patellar pain and, subsequently, lameness and periodic spells of undue fatigue. Left-sided radiculitis was initially considered. A diagnosis of tuberculous coxitis was made later, and a plaster cast was used for 6 months.

X-ray follow-up after removal of the cast provided the basis for the diagnosis of Perthes' disease, and the patient was sent for sanatorium treatment.

The patient was of medium height, proportional build, adequate nutrition, had well-developed musculoskeletal system. Abdominal and thoracic organs were normal. There was a 2-cm shortening of the left leg and a 1-cm contraction of its circumference. The Aleksandrov symptom was negative. The fibrous capsule was painful on palpation. Movement of the left hip joint was painful and restricted, especially abduction.

X-rays showed a mushroom-like deformity of the head of the femur, a wide articular slit, a reduced angle between the neck and diaphysis of the femur. There were no signs of deforming arthrosis or tuberculous coxitis.

The patient was given balneo- and fango therapy concurrent with medical exercises and prescribed walking. A 45-day course of therapy resulted in the termination of pain, a 25 per cent increase in the articular range, and a significant improvement in the static function of the leg; the patient did well, and was discharged with a significant improvement. Discharge instructions were a prescribed regimen, orthopaedic shoes, and resort treatment. The patient visited resorts for four consecutive years. The function of his hip joint and working ability were substantially restored, and the patient resumed his occupation as an engineer.

Great diagnostic difficulties are posed by bilateral involvement of epiphyses and thighbones, since Perthes' disease is accepted to be unilateral. However, according to reports in the literature (Reinberg, Rokhlin, Perthes) and our own observations, bilateral aseptic necrosis of the head of the femur can be encountered, although very

Fig. 37. Osteochondropathy of the left femoral neck following Perthes' disease in patient A., 56 years.

rarely. We have had a chance to see 8 cases among the great number of patients with osteoarticular diseases at the large resorts in the USSR (Saki, Evpatoria, Pyatigorsk). The characteristic feature was the development of a pathological process in the left head of the femur, subsequently involving the right head. These patients were as a rule erroneously diagnosed as having bilateral infectious coxitis and secondary osteoarthrosis.

Moreover, it should be remembered that osteochondropathy of the femoral head may be accompanied by tuberculosis of the head. Tuberculosis is usually complicated by necrosis of the head of the femur, and X-rays reveal symptoms of both diseases (Kornev, Reinberg).

Following is an example of case history.

Patient K., 21 years old, was admitted to a sanatorium of the Evpatoria resort because of tuberculous coxitis. The patient was proportionately built and undernourished; the skin slightly pale. Thoracic examination showed normal heart boundaries, tachycardia, sonorous heart sounds, and normal lungs. The abdominal organs were normal. The left thigh was in a flexed position, with sharply restricted abduction; muscles hypotrophic. There was a prominent vascular pattern of the skin. Pasty soft tissues at the coxofemoral joint and thickening of the joint capsule were seen on palpation; the greater trochanter was painful on percussion and during straining of the coxofemoral joint. Pelvic muscles were hypotrophic, and there was a slight pelvic anteversion. The left knee joint showed a flexion contracture. The Aleksandrov symptom positive.

Blood test: hypochromic anaemia (Hb 46%), lymphocytosis, and moderate leukocytosis.

X-ray findings: the femoral head was displaced upward and outward, osseous atrophy and destruction, marked osteoporosis, and a site of necrosis in the acetabulum area.

The inflammatory and necrotic process in the femoral head was confirmed by a series of X-rays.

The above findings led to the diagnosis of Perthes' disease with tuberculous coxitis.

The presented evidence shows that the diagnosis of osteochondropathy of the femoral head may pose considerable difficulties. An accurate evaluation of the disease is based on thorough study of the medical history and comprehensive clinical and X-ray examinations. Congenital systemic diseases (chondrodystrophy, multiple cartilage exostoses) and deforming osteoarthritis must be considered in osteochondropathy of the hip joint like Perthes' disease. Chondrodystrophy is known to be a disorder of longitudinal growth of bones associated with inappropriate enchondral ossification, with peri- and endosteal transverse growth being normal. The process occurs symmetrically; the width of the epiphyseal cartilage area is highly variable, accounting for various locations of the epiphyseal nucleus as reported by Reinberg: separate in the saucer-like impression of the metaphysis, fusing with the metaphysis shadow, or barely recognized in an X-ray.

Multiple cartilaginous exostoses must be considered in diagnosing osteochondropathy; they grow especially rapidly during puberty. Exostoses usually grow symmetrically, varying from the size of a small pea to that of an apple; their surface is often tuberous. Exostoses may cause irradiating pain in the joint or a feeling of tension. These features must be taken into account in differentiating between cartilaginous exostoses and osteochondropathy of the femoral head.

The prognosis of osteochondropathy is, on the whole, favourable; however, in our experience, Perthes' disease may be protracted and induce persistent marked anatomic and functional disorders in 20-25 per cent of patients, resulting in a lower working ability (in half of patients) or even transient disability.

Therefore, it is of practical importance that such patients receive early therapy, especially resort care.

14.2. Osteochondropathy of the Tibial Tubercle (Osgood-Schlatter's Disease)

Disease of the tibial tubercle was reported by Osgood and Schlatter in 1903. The disease is rather common, although its incidence is lower than that of Perthes' disease. It usually occurs between the ages of 12-17, more often in boys.

Its onset usually occurs for no apparent reason (for patients); sometimes the disease is preceded by trauma. The major symptoms are knee pain (it was seen in 46 patients), swelling at the site of the tibial tubercle (34 patients), and a difficulty of flexion of the knee joint (19 patients).

Examination usually shows a localized convexity at the site of the tibial tubercle. Palpation is painful, and shows a marked roughness. Patient's complaints and abnormalities in the lower portion of the knee joint attract the attention of a physician to the joint rather than the tibial tubercle. X-ray findings help greatly in making a correct diagnosis. If the clinical picture is typical, an X-ray shows hardened sites interspaced with structure-devoid elements, the borders of tubercle being rugged, as it were. Sometimes a fracture line is seen in a tubercle which is pulled upward and displaced by the patellar ligament. The most important symptoms of aseptic necrosis of the tibial tubercle are severe structural abnormalities with sequester-like formations and significant tubercle deformities which show up in X-rays.

This case history is presented as an illustration.

Patient N., 22 years old. She was admitted to the clinic with a diagnosis of toxic infectious polyarthritis. She reported the disease to occur at the age of 14 when pain and swelling appeared in the left knee joint; there were periodic

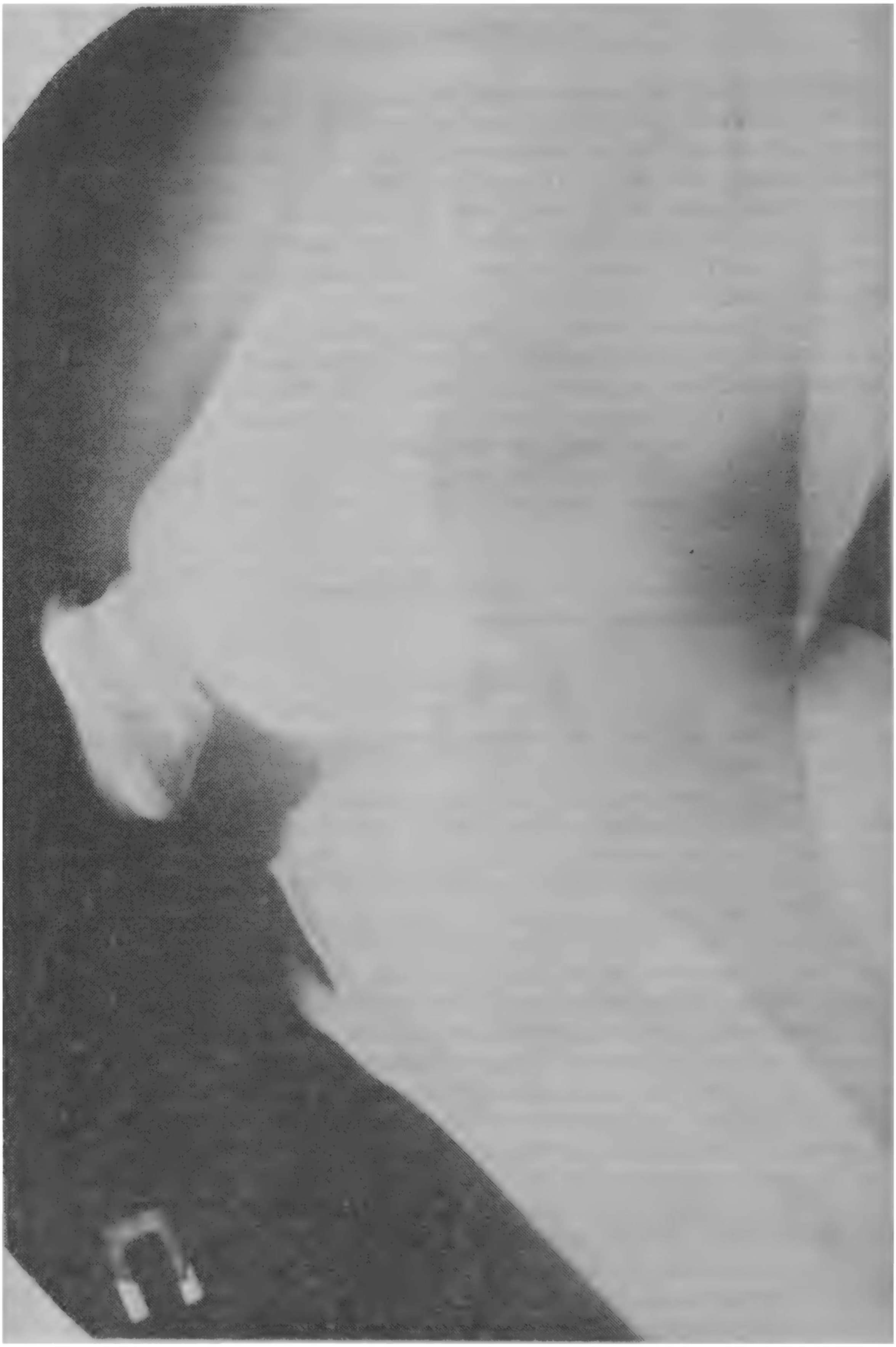


Fig. 38. X-ray of patient with Osgood-Schlatter disease (the right tibia) in pati... K., 21 years.

convulsions in leg muscles. After an episode of influenza in 1955, the pain recurred in this and appeared in other joints.

The patient was of medium height, proportional build, and adequate nutrition. Thoracic and abdominal organs were normal. An examination of the locomotor system showed a well-developed musculoskeletal system; pain at the site of the left tibial tubercle, pasty soft tissues and rough hardening of the osteocartilaginous tissue were observed on palpation. The range of movement in the knee joint was somewhat restricted.

An X-ray of the tibial tubercle showed left-sided abnormalities characteristic of aseptic necrosis of the osteochondropathy type (Osgood-Schlatter's disease).

Blood tests were normal.

Osgood-Schlatter's disease was diagnosed.

The patient received 17 radon baths, 9 mud packs on the knee joint, 23 medical exercises and massage (10 procedures). She was discharged with an improvement.

The disease usually continues for 1.5-2 years. The prognosis is favourable. The duration of the disease can be significantly reduced by the early use of thermal and physiotherapeutic procedures. Bed rest and warm compresses are indicated during an acute period.

The Osgood-Schlatter disease is to be differentiated from tuberculosis of the tibial tubercle, osteosarcoma, traumatic tear of the tubercle, and inflammation of the bursa located behind the patellar ligament proper.

14.3. Osteochondropathy of the 2nd and 3rd Metatarsal Bones (Köhler's Disease)

Necrosis of the navicular bone was described by Köhler in 1908. Six patients with the 2nd metatarsal bone disease occurring as fissure of the bone head were later (1914) described by the American surgeon Freiberg. Since 1920, over 400 patients with this disease have been reported in the USSR. Therefore, this form of osteochondropathy is not rare. In contrast to Perthes' disease, its incidence is 4 times higher in 12-16-year-old females. Since two locations of this disease were reported by Köhler, osteochondropathy of the navicular bone is referred to as Köhler osteochondropathy I, and osteochondropathy of the metatarsal bone head as Köhler osteochondropathy II.

Patients usually find themselves to have the disease after twisting their foot, running accidents, etc. It is common in female weavers who work standing for long hours. The major complaint is pain: all of our patients (31 persons) voiced this complaint. Sometimes the pain appeared suddenly, growing during walking.

Deformity and thickening of the affected joint are characteristic of 2nd metatarsal bone osteochondropathy. The pain is greater on palpation of the affected joint. The articular range is usually restricted. No clinical signs of an infectious disease are seen; tuberculosis-

Fig. 39. X-ray of female patient I., 46 years with Köhler's disease, aseptic necrosis.

or suppuration-specific findings (tissue destruction or fistulas) are absent.

X-rays are helpful in making the diagnosis. Initial X-ray abnormalities are flattening of the bone head, its more prominent outline, and widening of the articular slit. In the second stage, the enlargement of the bone head is associated with structural abnormalities: loss of a spongy pattern, softening of the bone epiphysis, indistinct epiphyseal outline, expansion of the articular slit. Sequester-like shadows, periosteal deposits, and enlarged metatarsal metadiaphyses are seen in the third stage. In the latter stage, there is a typical picture of deforming osteoarthrosis. The head of the metatarsal bone is deformed and enlarged, the articular slit may be widened or narrowed.

Destruction of adjacent joint surfaces (osteoporosis, narrow articular slit, fistulas, ankylosis) is actually never seen in metatarsal osteochondropathy, making the diagnosis much easier.

Köhler's disease must be differentiated from infectious inflammatory and purulent processes, and from tuberculosis.

An illustration is the case history presented below.

A girl patient T., 15 years old, was referred to the Saki resort because of pain in her outer foot. The pain increased with walking. Moving the 1st-2nd-3rd toes of the right foot caused pain in the 2nd metatarsal bone.

The patient was of medium height, and good physique and nutritional status. The musculoskeletal system was normally developed. Thoracic and abdominal organs were normal.

The outer surface of the foot had a small swelling. Palpation showed tuberosity and deformity of the head of the 2nd metatarsal bone.

X-ray findings: the epiphyseal head flattened and shortened by 2 times, the spongy bone had a structureless shadow. The articular slit is somewhat widened.

Blood test: Hb 74%, erythrocytes 4 100 000, leukocytes 6200, eosinophils 2%, stab neutrophils 2%, segmented neutrophils 60%, lymphocytes 30%, monocytes 6%, ESR 12 mm/hr.

The patient was given 12 mud packs (42 °C) of 15-minute duration at an interval of one day, and massage. She was discharged with a considerable improvement.

Resort treatment is virtually always effective in this osteochondropathy, but persistent joint disorders (bony outgrowths) with severe pain require surgery.

14.4. Osteochondropathy of the Condyle of the Femur (König's Disease)

This disease was reported by König in 1905. It is characterized by protrusion of a wedge-like piece of the bone from the body of the medial condyle of the femur, with a lesion resulting in this area.

König's disease is believed by some authors (Lexer, Tabby) to result from embolic infarction of branches of the median popliteal artery which may be injured at the site of the posterior cruciate ligament. Necrotic sites are resorbed as they are small. The articular mouse is often formed as the necrotic bone site falls into the joint cavity. All patients complain of dull pain in the knee joint and slight difficulty on flexion. Severe pain in the joint abruptly appears in impaction of the articular mouse. Conservative treatment is indicated if the bone tissue adheres to the condyle. Repeated impaction requires surgery.

This case history is presented as an illustration.

Patient S., 36 years old, came to the Saki resort because of pain in the left knee joint. Left-sided gonitis had been diagnosed.

The patient was proportionally built, and of adequate nutrition. The musculoskeletal system, thoracic and abdominal organs were normal. The patient complained of pain and stiffness in the left knee joint. The joint was painless during medical exercises, and rotation produced pain in the inner condyle of the femur.

An X-ray showed an oval body, separate from the inner condyle of the left femur, yet slightly adhering to the bulk of the bone.

Fig. 56. X-ray of patient G., 61 years with König's disease (the right inn
femoral condyle)

The patient was prescribed locomotor training; in addition, he was given 14 mud packs (44 °C) of 15-min duration every other day, and medical exercises (14). The combined therapy resulted in a significant improvement on the time of discharge.

Bilateral König's disease is very rare.

Patient D., 42 years old, contacted us because of an abrupt severe burning pain in the left knee joint. The joint was swollen and very stiff. From the case history similar symptoms were assumed to have occurred in the right knee joint a few years ago.

The patient was of good physique and nutritional status. The musculoskeletal system was normally developed. The cardiovascular, respiratory and digestive systems showed no abnormalities.

A typical bilateral König's disease was seen via X-rays, located in the inner condyle of the right and outer condyle of the left knee joint. Articular mouse was present in both joints. Pain attacks, joint swelling and stiffness were associated with impaction of articular mouse. These symptoms were rapidly alleviated by rest and thermal applications.

Bilateral König's disease was seen in only one of 46 patients under our observation.

Osteochondropathy may have locations other than the condylar: in the pubic bone, sternal end of the clavicle, semilunar bone of the wrist (Kienböck's disease), body of the vertebra (Calvé's disease), etc. These diseases are omitted because they are rarely encountered in resort practice.

14.5. General Comments on Resort Treatment of Patients with Osteochondropathy

Patients with osteochondropathy are usually referred to sanatorium/resort institutions because of pain in the joints and impairment of locomotor function. Resort treatment has beneficial effect on reparative processes in the affected area, resulting in pain relief. Compensatory neuromuscular mechanisms and hardening of patients are also improved by it. Mud therapy is preferable to balneotherapy for osteoarthritis with articular range restriction or stiffness in the hip, knee or other joints, and for inflammatory osteoarticular disorders with severe pain.

Medicinal mud has high anti-inflammatory, resorptive and analgesic effects; it alleviates the course of a disease within a relatively short period, and, what is more, improves the long-term outcome of osteochondropathy. The mud is applied to the affected area. Thus, it is applied to the upper shin in Osgood-Schlatter's disease, to the knee joint in König's disease; sock packs are used in Köhler's disease, and shorts packs in Perthes' disease. Mud packs of median temperatures must be used (42-46 °C), the procedure lasts 15-20 minutes. Mud is applied on two consecutive days, with a break on the 3rd day.

If mud therapy is contraindicated, usual hydrogen sulphide, hydrogen sulphide-carbonate or radon baths may be employed. Apart from bath and mud procedures, the comprehensive care must include therapeutic exercises, mechanotherapy, and massage. Orthopaedic care is also required. According to the clinical course and functional response, simple bandages or special devices are used to reinforce, relieve or correct the locomotion. This is especially important after exercise training and resort treatment.

Therefore, to improve the functioning of the affected limb and prevent secondary locomotor disorders (spinal curvatures, axial abnormalities in the limb, etc.), proper orthopaedic measures should be prescribed during the patient's stay at the resort.

Chapter 15. Diagnostic and Balneotherapeutic Mistakes in Diseases of Joints

Today a lack of knowledge still remains in some essential areas of diagnosis and therapy of locomotor diseases. Even what is known may not be made accessible to the general physician, as is the case with abdominal and thoracic diseases. As a result, physicians face great difficulties in diagnosing diseases of joints. This leads to a great incidence of diagnostic mistakes and therapeutic failures.

This knowledge deficiency seems to be associated with an inadequate proportion of arthrology in the internal medicine syllabus of higher schools, and a lack of texts in this speciality. Patients with diseases of joints are managed by specialists inadequately trained in diagnosis and therapy of locomotor diseases. Great numbers of patients with articular diseases are sent for resort treatment with inaccurate or even false diagnoses.

At resorts great numbers of patients with various diseases of joints are concentrated and, therefore, resort physicians gain arthrologic experience and skills in diagnosis and therapy.

Patients come to resorts with a diagnosis of *ischias* or *rheumatism*, although uni- or bilateral femoral dislocation is present in some of them. Diseases of different localizations (elbow, foot, shoulder, knee), unrelated neither aetiologically nor pathogenetically, are mistaken for systemic diseases of rheumatoid origin. Thus, typical elbow bursitis, foot pain in a typically located inappropriately knitted fracture of the outer ankle, shoulder-joint stiffness due to bursitis calcarea, and restricted knee-joint movement due to injury are interpreted as *rheumatism*.

Patients with hallux valgus are sent to resorts because of *gout* rather than for the purpose of receiving specific therapy (usually middle-aged females). Hallux valgus is most commonly associated with a bursal exostosis which may be corrected by surgery. Yet the patients are prescribed a strict diet, restricted activity, and sent for resort treatment.

Sometimes a false diagnosis of osteoarticular tuberculosis is made and plaster casts are applied for a long period, although the patient suffers a disease, in which immobilization is not indicated

and, moreover, precluded (Perthes' disease, residual infectious coxitis) because it impedes functional recovery of the locomotor system.

Clinically observed and proved by X-rays a calcaneal spur does not imply a gonorrhoeal origin, as often assumed by physicians. In fact, calcaneal spurs often occur because of infections (angina, influenza), metabolic, degenerative or other disorders. Therefore, the physician failing to define the aetiology of disease is misled both in diagnosis and therapy. Physicians likewise err in diagnosing infectious joint disease when they neglect to consider its clinical course. This is also a therapeutic mistake, since the physician overlooks the possibility of using effective drugs or procedures (antibiotics, hormones, physical factors, vaccines, exercises) concurrently with resort treatment in patients with infectious polyarthritis.

Numerous joint diseases are known to be related to local infections, most commonly harbouring in pharyngeal tonsils, carious teeth, accessory nasal sinuses and facilitating disease relapses and exacerbations. Surgical removal of these foci often results in a milder clinical course, absence of relapses, and alleviation of inflammation in the joints. Early care of these infections is of paramount importance.

The application of resort treatment without using the mentioned measures is usually unrewarding and, sometimes, aggravates the disease. This conservative therapeutic approach is undoubtedly a mistake. Tonsillar or odontogenous infections may lead to greater trouble in the presence of a rheumatic disease.

Sending of patients to resorts after rheumatic attacks, even as months (4-6) elapse after an acute period, without first eliminating the local infections, is a mistake, to say the least, since this may cause severe, life-threatening complications during the resort treatment (relapsing or chronic septic endocarditis, etc.).

It should be remembered that the common cold is a contributing factor in rheumatic polyarthritis. So it is the physician's obligation that resort treatment is conducted under conditions which prevent overcooling. Overcooling may result in a relapse of rheumatoid polyarthritis. The patients usually experience a flare-up of chronic tonsillitis followed by a polyarthritis relapse. It may happen that the relapse only represents a causal relationship between the local infection and articular inflammation.

Still greater confusion exists in differentiating between rheumatoid arthritis and deforming arthrosis. The primary chronic joint disease may result in joint deformity because of frequent relapses of inflammation and pathologic involvement of osteocartilaginous elements. The origin of the primary chronic joint disease is very elusive in young and premenopausal females. Identification of endocrine-vegetative relationships and X-ray patterns of pathoanatomic bone

disorders are of crucial significance in such cases. The proper differentiation is the basis of successful therapy and prevention of relapses of infectious arthritis, and of primary chronic destructive progressive polyarthritis.

As has been said, inaccurate diagnosis is a major cause of unsuccessful resort treatment of patients with joint diseases. An example is *rheumatism* diagnosed in patients with various osteoarticular diseases which are actually tuberculous diseases of the locomotor system, or associated joint diseases with peripheral vascular and neural involvement, although masked.

Certainly, identification of a tuberculous joint disease is often problematic, especially when the synovial membranes are involved. In such cases, on an erroneous assumption of a non-specific infectious disease in the joints, the physician prescribes bath and mud therapy, during which the patient develops a progressive exacerbation fraught with serious danger.

We present the following case history as an illustration.

Patient I., 34 years old, was admitted to the Pirogov Sanatorium of the Pyatigorsk resort because of bilateral traumatic gonitis. The patient had a history of lung tuberculosis. A few months before admission to the sanatorium, the patient had been hospitalized because of a bruised right knee joint.

Upon hospital admission, *traumatic arthritis* was diagnosed, and a plaster bandage was applied for 2 months. Physiomechanotherapy was subsequently used, but it was ineffective, which was the reason for sending the patient for resort treatment. In the sanatorium, infectious gonitis was diagnosed, and 44 °C mud packs were prescribed, 15 minutes for 2 consecutive days, with a break on the 3rd day.

After the 6th mud pack, joint pain and swelling severely worsened; local fever and impairment in the locomotor function and the general condition occurred. A comparison of anamnestic, clinical and X-ray findings (the history of tuberculosis, the recent knee-joint bruise, diffuse opacity in the upper recess and forward displacement of the kneecap seen in an X-ray) led us to diagnose the synovial form of joint tuberculosis.

Mud therapy was withdrawn, the right leg was immobilized, and streptomycin given. This therapy resulted in alleviation of the specific inflammatory process in the synovial membrane, and the patient was referred to a local clinic for further treatment.

Thus, misdiagnosis and irrelevant therapy caused an aggravation of a tuberculous process in the affected joint. Diagnostic and therapeutic mistakes may lead not only to exacerbations of a disease but to more severe, even life-threatening conditions. Therefore, physicians must carefully evaluate the patient's history and the relationship between manifestations of joint disease and anamnestic diseases, so that indications for and a mode of resort therapy are correctly defined.

Patients' lives are not infrequently endangered by misdiagnosis and irrelevant resort prescriptions.

This case history is presented as an illustration.

Patient K., 27 years old, was admitted to the Pirogov Sanatorium with right-sided infectious coxitis. A detailed evaluation of the anamnesis showed a history of pulmonary tuberculosis which was treated in special institutions; as a result of treatment, the pathological process subsided. Two years later, the patient began to feel pain in the right hip joint; there was an articular range restriction, muscle hypotrophy of the right gluteus and thigh, and impairment of the static function.

The diagnosis of infectious coxitis was proven by X-rays. Interpreting the process as a manifestation of infectious coxitis and unaware of the tuberculosis, the physician prescribed hydrogen sulphide-carbonate baths.

After 8 baths the general condition severely worsened, and there was a fever (40°), severe pain in the hip joint, stabbing chest pain, cough, accelerated shallow respiration, tachycardia (heart rate 90-110), and marked intoxication. Pneumonia was diagnosed, and balneotherapy was withdrawn. An X-ray examination revealed miliary tuberculosis of the lungs.

A combined anti-tuberculous therapy was instituted. The patient's condition remained critical for several days, but it was alleviated and the tuberculosis was abated by vigorous use of streptomycin, PASA, vitamins and other supporting therapy. The patient's condition was satisfactory upon discharge.

The above case history obviously indicates that the physician's blunder was to ignore the history of tuberculosis. Inadequate clinical, laboratory, and X-ray examinations, and the institution of balneologic therapy which was obviously contraindicated and life-threatening were also mistakes.

Of course, to diagnose tuberculous diseases of bones and joints may be quite difficult, yet tuberculosis of the locomotor organs must be strongly considered as the disease is evaluated.

We will cite examples of the gross mistakes of diagnosing tuberculosis of bones and joints where it is absent. Patients with banal injuries or acute common infections of bones and joints were misdiagnosed as having tuberculosis, and unnecessary joint immobilization was used, resulting in joint rigidity, locomotor impairment, loss of working capacity, and invalidity.

People who never had tuberculosis and were healthy and work-efficient are made unhappy as they are said to have it and compelled to spend years visiting different medical institutions, seeking a cure for the nonexistent tuberculosis. Such patients have to wear plaster jackets or casts, use crutches or walking-sticks, as recommended by physicians, and go to different resorts, seeking medical care.

These patients are unaware that the only cure of 'tuberculosis' is to dismiss the jackets, casts, crutches, sticks, and to use active exercise and return to work.

If everything that is known were utilized in the care of patients with osteoarticular diseases, osteoarticular tuberculosis would not be diagnosed where it is absent and would not be misdiagnosed where it is obvious. It would lead to more appropriate use of resort therapy, eradicating fatal, life-threatening mistakes.

A sensible approach to diagnosis and therapy of patients with osteo-

Fig. 41. X-ray of patient G., 38 years with enchondroma of the fifth phalange.

articular diseases would make various therapeutic complexes, including sanatorium-resort treatment, more effective.

Moreover, a serious mistake is made when patients with benign or malignant neoplasms (osteoma, sarcoma, etc.) misdiagnosed as arthritis are sent to resorts.

To illustrate:

Patient P., 52 years old, was admitted to the Lenin Sanatorium of the Saki resort with diagnosis of *polyarthritis* predominant in the 1st-2nd-3rd finger joints and metacarpal bones of the left hand.

The patient complained of pain and rigidity. Objective findings were deformity of the left hand, dense nodes on the palm surface, rigidity of the fingers and

radiocarpal joint, hypotrophic and weak muscles. No inflammation in the hand was seen.

An X-ray diagnosis indicated osteochondromas of the left-hand fingers. Resort treatment was cancelled.

It is a lamentable mistake to send a patient with right-sided fibular neuritis and right-sided talocrural arthritis for resort treatment.

Patient K., 39 years, was admitted to the Pirogov Sanatorium of the Pyatigorsk resort with the above-mentioned diagnosis. The patient complained of shooting pain in the right shin and the right ankle joint, rigidity of the joint, swelling of the lower shin, general weakness, and undue fatigue.

Objective findings were mild oedema of the soft tissues in the lower third of the right shin, and 12 × 4 cm calf-bone induration with an irregular outline and tuberous surface. The ankle joint was rigid.

Osteosarcoma of the lower third of the left fibula was identified by X-rays. The patient was sent to his place of residence for surgery.

The presented case histories are obvious evidence that the referring physicians blundered by not conducting a thorough examination of a patient having ignored an X-ray diagnosis. Even an inexperienced physician could have made an accurate diagnosis on seeing an X-ray.

It is of practical interest to consider locomotor diseases combined with peripheral vascular and neural lesions. Consulting a physician because of pain in the joints, patients focus the physician's attention on the joint status, and s(he) is often distracted from the peripheral neurovascular status. Also, only the neurovascular system may be examined by a physician if the patients complain of pain in the extremities which is not located in the joints. In either case, a diagnostic, hence therapeutic, mistake is made.

An illustration of this is presented by the following case history.

Patient S., 42 years old, was admitted to the Pirogov Sanatorium because of *infectious non-specific polyarthritis*. The patient's complaints were pain in the joints and in the left eye, undue fatigue, foot chills, general weakness, sleep disorders, and lower working ability.

Objective findings were lower temperature of the foot skin, especially in the left, mild left-foot cyanosis, soft-tissue pastiness around the ankle joints and indistinct outline of the joints, joint crepitation in plantar flexion, moderate stiffness. Conjunctival hyperaemia and punctate haemorrhage were seen in the left eye.

X-ray examinations and laboratory tests were normal.

Conventional hydrogen sulphide-carbonate baths were prescribed. After 8 baths the pain suddenly got worse in the left leg, there was severe oedema of the lower shin and cyanosis of the foot skin; pulsation was absent in the outer foot artery and posterior tibial artery. Pain also intensified in the left eye.

This led to the diagnosis of arterial thrombosis of the left shin. Balneologic therapy was withdrawn, and anti-thrombotic therapy instituted.

A detailed evaluation of the clinical data suggested that the primary disease was endarteritis obliterans of the lower extremities

Fig. 42. X-ray of patient E., 11 years with osteosarcoma of the left femur.

and the eye rather than polyarthritis. The diagnostic mistake consisted in that the physician focused on the joint disease overlooking the possibility of these symptoms in a vascular disease. If the pulses of the foot arteries were examined upon sanatorium admission and the findings were compared with the clinical picture, the diagnosis of endarteritis obliterans would have undoubtedly been made or at least considered.

Numerous similar mistakes in diagnosis and resort therapy of patients with diseases of joints might be presented, but those presented above suffice to demonstrate the utmost importance of detailed examination of patients and evaluation of the onset and evolution of a disease. If these requirements are not met, resort therapy, a great expectation of patients and physicians, may result in fatal mistakes and complications.

Chapter 16. Long-Term Results of Resort Therapy in Diseases of Joints

Experience of resort care of patients with various diseases of joints has clearly shown that in the vast majority of patients (80-90 per cent), there is both general and locomotor improvement by the end of therapy.

An assessment of its immediate effect is based on the sum total of subjective and objective changes in the general condition and in the local disease as judged by functional and anatomic alterations in the locomotor organs.

To assess the short-term effect is of great objective value. However, the posttreatment effect obtained under artificial favourable conditions (which may be quite different from the usual living conditions of the patient) still have a relative significance.

Verification of the stability of therapeutic results is possible only upon the patient's return to his/her daily routine. Only then can a true therapeutic response and locomotor adjustment to environmental conditions be evaluated. Furthermore, some indices of efficacy of resort therapy, such as working capacity, resistance to infections, compensatory locomotor mechanisms, cannot be revealed during the patient's stay at the resort or in the hospital, and, thus, a later follow-up is required.

Finally, resort care represents only one of many medicoprophylactic measures; it cannot be isolated from previous hospital or polyclinical care, nor from subsequent follow-up observations after resort treatment.

Follow-up examinations after resort treatment and the assessment of long-term results enable us

(a) to objectively evaluate the applied criteria in terms of therapeutic efficacy and determine the best of them;

(b) to identify the most advantageous therapeutic factors and their combinations, to substantiate differentiated therapeutic methods;

(c) to find out relationships between the form of a diseaso and the results of therapy and stability of improvement so as to specify

indications and contraindications for resort therapy of different diseases of joints;

(d) to find out the basis of exacerbations and relapses for devising an efficient system of prophylactic care.

However, papers on the analysis and evaluation of long-term results are lacking in the clinical and balneologic literature. There are no integrated definitions of the immediate, short-term and long-term results. Moreover, there is a confusion in this area. Some authors (Nudolskaya) speak of primary and long-term results, while others (Lebedeva) term them short- and long-term.

Follow-up periods have not been specified either. Thus, according to Krotova, the long-term evaluation requires that patients are followed up for 3 months at 12-day intervals and, subsequently, for 5 years annually. Lebedeva suggests that patients be examined once every 5 years. Yavorsky proposes a period of 20-30 days to evaluate short-term results of therapy. According to Atreshchenko, the long-term results should be evaluated annually.

The role of continuing therapy and methods of exploring the causes of relapsing or deteriorating disease are ignored. Naturally, this affects prophylactic care and effective therapy.

It is important to monitor both immediate and long-term therapeutic results, giving priority to the latter. In fact, the definition of short-term and long-term results is associated with the form of the disease (chronic and acute infections, metabolic disorders, malignancy, chronic inflammatory diseases) and methods of treatment (surgical, medical, physiobalneologic, etc.). With regard for the specific features of resort therapy, we think that the long-term results in patients, primarily in those with chronic disease, must be defined within one year after sanatorium-resort treatment. This view is supported by the fact that labour legislation provides for workers to take a leave and the opportunity for another leave and medical care not less than once annually.

Because of the urgency of the problem, a study of the immediate and long-term effect of resort therapy on patients with various joint diseases has been undertaken by us in recent years. On the basis of our experience, we recommend for clinical practice the use of the terms 'immediate', 'short-term', and 'long-term' results.

The *immediate* results are evaluated at the end of therapy (usually upon discharge); *short-term* results are assessed within the first 3-4 months after therapy, since certain therapy-associated changes continue to occur in the body; *long-term* results are defined within one year following resort therapy. Another reason for our choosing this period is that changes determined by factors other than the resort therapy may take place after one year.

The methods for evaluating the long-term results were:

(a) systematic (at 3, 6, 9, 12 months) interviewing of patients by

questionnaires; the questionnaires were filled out by both the patients (subjective evaluation) and the local attending physicians (objective patient status and selected laboratory findings at the time of interviewing);

(b) evaluation of the long-term results upon readmission to sanatoria one year after the therapy;

(c) examination of patients at their place of residence.

In addition, we recruited local specialists who resided in areas where the greatest numbers of resort-treated patients are concentrated, and who were engaged in the local care of patients.

The data on the long-term results were subjected to a clinicostatistical analysis and compared with the immediate effect of therapy. Moreover, the data were statistically processed to define their representative value. The tabulated data on quantitatively different groups of patients were evaluated for their statistical significance.

Experience of studying the long-term results for many years has shown that our methods were justified, although each of them had its advantages and limitations.

The most reliable clinical data were obtained by the examination of patients upon readmission and by the evaluation of the data by physicians visiting the patients' place of residence. Yet only small groups of patients (18-20 per cent) can be examined with this method, and the results of these studies do not apply to the overall population with similar diseases. Also, the examination of patients upon readmission or by contacting them locally can be made only once, whereas interviewing by questionnaires allows regular follow-ups.

The questionnaire permits follow-ups of great number of patients, without spending much time and money, and the tracting of the outcomes of most patients, thus making the study results applicable to all patients of the target nosological groups.

On the other hand, the questionnaire method has serious shortcomings:

(a) an accurate and careful patient response is not always obtained, and the regular follow-up is hindered;

(b) the questionnaire response is often subjective, and may not be accurate as to the objective status of the patient;

(c) local attending physicians lack communication with resort institutions, and may not realize the importance of patient follow-ups after resort treatment and so inaccurately respond to the questionnaire items concerning the patient status.

These shortcomings might be eliminated by designing a regular integrated system of combined therapy and follow-up both at resorts and places of residence committing the physicians to coordinated activities in this real undertaking of prophylactic medicine.

A comparison of long-term and immediate findings shows the

extremely important fact that, in a considerabl
tients, the best therapeutic effect is obtained not
but 1-3, even 4 months after therapy. The in
patient's general condition, continuing after res
the abatement of joint disease symptoms are
what physiologists described as after-effect, one ph
of resort factors on the body (Prokopenko, Pis

Study results have shown that the long-term
apy is favourable in diseases of joints: the imm
response is preserved for various periods in m
rheumatoid, degenerative brucellous, and other

The immediate results of therapy in patient
polyarthritis, in our experience, were actual recov
significant improvement in 8.4 per cent, an im
per cent, absence of response in 2.1 per cent, a
disease in 1.1 per cent.

A higher efficacy of therapy was seen in patie
arthrosis: recovery in 6 per cent, significant im
per cent, and an improvement in 81.6 per cent;
unresponsiveness were not observed.

Patients with brucellous polyarthritis compris
portion of patients with infectious polyarthritis
of these, a significant improvement was noted
an improvement in 82.6 per cent, absence of resp
and exacerbations of a disease during therapy in 2

Poor outcome of resort therapy was more oft
tients with knee arthritis and destructive progre
respectively, in 7.3 per cent and 11.5 per cent.
short- and long-term results of therapy has reve
tions. They are preserved for 3 months in 76.5 p
for 6 months in 47.9 per cent, and for one year i
should be stressed that in the majority of pati
results in a significant alleviation of clinical
inflammation, but, in a number of cases, no subje
is noted.

It is interesting to consider the duration of th
patients with brucellosis treated at resorts acco
and stage of a disease, the presence or absence
diseases, the employed resort therapy, the imm
results, and the living and working conditions afte
To this end we have analysed the duration of ren
tients with brucellous polyarthritis, who were
and responded to the questionnaires at different
resort treatment. The therapeutic effect was pre
first 3 months in most of the patients, regardless o
forms were. The stability of the therapeutic effec

was greatest in patients with the locomotor form of brucellosis. In locomotor brucellosis, the therapeutic effect was retained for up to one year in 25.4 per cent of patients, whereas in clinically combined forms it was noted within this period in only 14.8 per cent. A comparison of long-term results of resort therapy in patients with compensated and subcompensated disease showed that the effect of resort therapy lasted longer in the former group. It was retained for up to one year in 26.7 per cent of patients with chronic brucellosis of compensated stage, whereas it was retained in only 13.5 per cent of patients with chronic brucellosis of subcompensated stage. The difference in the stability of response to resort therapy in these patients was still greater at a later period (after several years). Within this period, the effect of resort therapy was retained in 12.4 per cent of patients with compensated brucellosis and in 4.4 per cent of patients with subcompensated disease.

It was of interest to explore the relationship between the long-term results of resort treatment and concomitant diseases in patients with polyarthritis (cardiovascular, neural, digestive, etc.). A comparison of the stability of the therapeutic results in patients with chronic polyarthritis and concomitant diseases with those in patients not having them showed that the therapeutic effect was preserved mainly in patients with no accompanying diseases (84.3 per cent versus 69.2 per cent). It was especially manifest when the stability of the therapeutic effect and functioning of the central nervous system were examined. The stability of the effect was found to be inversely correlated to the severity of neurotic responses. The therapeutic effect lasted during one year after resort therapy in 28.4 per cent of patients with mild or absent neurotic responses, and in only 11.6 per cent of patients with severe neurotic responses.

To examine the relationship between the immediate and long-term results of resort therapy, we compared them in a group of patients with chronic locomotor brucellosis, categorizing the results into good, satisfactory, and poor. Therapy outcome was qualified as good in patients preserving the therapeutic effect for at least 6 months after resort treatment, as satisfactory in patients preserving it for 3-6 months, and as poor in patients in whom the effect lasted for less than 3 months. The best outcome was seen in patients with joint diseases who demonstrated a significant improvement or an improvement upon discharge. However, an improvement lasting for a few months after resort therapy was observed in a group of patients who demonstrated no therapeutic response or deterioration upon discharge.

An analysis of the immediate therapeutic results showed that their absence is associated with the duration and severity of a disease, exudative-proliferative or destructive osteoarticular changes, late or persistent exacerbation; therefore, the improvement occurring

in these patients after resort therapy seems to be due to the after-effect of resort factors.

During resort therapy, a significant percentage of patients experienced clinically manifest adverse response to balneologic treatment. In order to find out how therapeutic efficacy and its stability are influenced by this response, we have examined clinicophysiological findings of 450 patients for the immediate and long-term results of resort therapy; exacerbation response during resort therapy was observed in 153 patients and after the end of therapy (3, 5, 10 and even 15 days) in 29 patients. The immediate and short-term results of resort therapy were better in patients who experienced persistent repeated exacerbations during the therapy (19 per cent) and in patients in whom they persisted even after the end of therapy (3.2 per cent). The therapy resulted in an improvement in 22 patients with a history of exacerbation. The follow-up of these patients showed that inflammation abated within 1-2 months, yet recurred shortly thereafter.

The analysis of the immediate and, particularly, long-term results in patients with a history of adverse response to resort therapy demonstrated a high and lasting efficacy of the therapy in these cases. This suggests that a clinically manifest exacerbation response is a positive fact in resort therapy.

Therefore, the physician treating patients with joint diseases has the task of preventing severe exacerbations. This requires the identification of an underlying cause, on the one hand, and objective methods for forestalling the exacerbations, on the other hand.

The exacerbations during resort therapy in 96 of 153 patients might be related to the absence of previous specific therapy or to reinfections sustained before the arrival to the resort. These patients required serious attention. Balneotherapy had to be changed for mitigated resort therapy combined with high-dosage antibiotic therapy. The evaluation of the long-term results of resort therapy in these patients showed that its effect lasted for 3 months or longer in two-thirds of the patients. The analysis of the unsatisfactory outcome of therapy in 32 patients showed that each of them suffered more than one exacerbation during the therapy, and the exacerbations persisted by the end of therapy in 14 of them.

These case histories are presented as examples:

1. Patient S. was admitted to a clinic because of chronic locomotor brucellosis of compensated stage. He was given combined therapy (radon baths, mud packs applied to most severely affected joints, medical exercises, insolation' which was well tolerated. However, after the 9th bath, the general conditior and joint pain were significantly aggravated; pain appeared in previously unaffected joints and in the spine. This exacerbation response remained throughou the therapy and persisted to the end of it. The patient was discharged with the exacerbation. An evaluation of the short-term results showed no improvemen in the general condition in 1 month following resort therapy. Pain in the joint:

persisted, and the patient was able to return to work only after 2 months. The patient was disabled during 5 months of the year following resort therapy.

2. Patient N. was treated for chronic destructive progressive polyarthritis. She tolerated well hydrogen sulphide-carbonate baths concomitant with local mud packs, medical exercises, and massage. In the process of resort therapy, she developed a mild exacerbation which alleviated after 3 days. The exacerbation recurred by the end of therapy (after the 12th bath-and-mud procedure); it was more severe, and persisted through discharge. As found out by the follow-up, the patient did not work for 7 months, and subsequently became disabled.

In some patients, the exacerbation response occurred at the end of therapy and was sharply pronounced (the group with deterioration upon discharge).

An illustration is the case history below.

Patient S. was admitted because of chronic gonoarthritis. Combined therapy was administered (radon baths, diathermy, therapeutic exercises, massage). After 9 procedures the general condition of the patient worsened, he began to feel pain in the right ankle joint and the left knee joint. Penicillin therapy failed to relieve joint pain. Soon pain appeared in the Achilles tendon, heel bone, and muscles of the extremities and the trunk. The balneologic therapy was stopped because of the severity of the exacerbation. Upon completion of resort treatment, the patient was discharged with deterioration.

The assessment of the long-term results showed a 9-months period of ill-health. Joint inflammation was recurrent, and the bursoligamentous system and osteoarticular elements, especially those of the left knee joint, were increasingly affected by every new relapse. In addition, the joints, intact before the therapy, became involved.

Thus, our clinical studies on the immediate and long-term results in patients with chronic polyarthritis have indicated a relationship between the severity of exacerbation response and the duration of the therapeutic effect.

We sought to clarify which balneologic or other therapeutic factors had the most beneficial after-effect on patients with chronic joint diseases. Our answer is presented in Table 21.

Table 21. Efficacy of Different Therapeutic Factors in Patients with Chronic Polyarthritis

Therapeutic factor	The rate of application		The best short-term therapeutic effect	
	No. of patients	%	No. of patients	%
Hydrogen sulphide-carbonate baths	496	55.7	270	54.5
Radon baths	246	27.5	161	65.3
Fango	148	16.8	112	75.7

A clinical assessment has shown that therapeutic mud packs had the best short-term effect in patients with chronic polyarthritis (75.7 per cent); the radon baths were the second most effective factor (65.3 per cent of patients), and the therapeutic effect of hydrogen sulphide-carbonate baths was the smallest (54.5 per cent of patients).

An assessment of the short-term results also showed that patients equally benefited from hydrogen sulphide-carbonate or radon baths and mud therapy during the after-effect period (during the 1st and 2nd months), but the duration of the after-effect varied. Hydrogen sulphide-carbonate baths and mud therapy produced equal rates of improvement within 3 months; the improvement rate was 2 times higher with radon baths. A further evaluation of the stability of therapeutic results demonstrated that the effect of radon therapy lasted longer than that of other factors. The outcome of resort therapy was retained over 6 months in 61.3 per cent of patients treated with radon baths, whereas the beneficial effect of hydrogen sulphide-carbonate baths and mud packs lasted only 6 months in 50-52 per cent of patients.

The working and living conditions of patients after resort therapy are of great importance in maintaining its effect, as was ascertained by questionnaire responses and anamnestic data of patients who had received repeated therapy. Under favourable working and living conditions, a poor long-term outcome of resort therapy was observed in 43 patients with rheumatoid polyarthritis (9.6 per cent) and 64 patients with brucellosis (14.2 per cent), whereas under poor working and living conditions, the rates were respectively 17.5 per cent and 28 per cent.

The preservation of the working capacity is of great significance in the assessment of resort therapy efficacy. It was established that 335 patients (74.5 per cent) with various joint diseases remained in their occupations and did not switch to easier jobs after resort therapy, and only 115 patients (25.5 per cent) were incapacitated. A greater representative value is indicated by the data on the working capacity of patients before and after resort therapy. Before therapy, 92.1 per cent of patients were incapacitated for 2 weeks to 1 year or longer because of periodic exacerbations of a joint disease. The working capacity of these patients was substantially improved by resort therapy: 54 per cent of patients took no sick-leave days during a year, 29 per cent were incapacitated for 3 months, 11 per cent for 6 months, and 6 per cent for one year. Therefore, the working capacity was improved by resort therapy in most patients.

An analysis of recurrent incapacitation and exacerbations in patients with joint diseases showed that they were induced by deleterious factors like overcooling, physical overstrain, neuropsychic trauma and intercurrent diseases in 234 patients (52 per cent). Severe incapacitation after resort therapy in another 15 per cent of

patients might be related to a history of exacerbation. It should be emphasized that 149 patients with brucellous polyarthritis had a history of repeated contacts with brucellosis-affected animals; therefore, reinfection (33 per cent) plays an important role in recurrent incapacitation. Reinfection not only aggravated the course of brucellosis but often led to acute episodes of it. It most commonly occurred when the patients' working and living conditions were unfavourable after resort therapy.

Studies on the long-term results of resort therapy may provide a new insight (e.g., prognostic) into certain clinical and laboratory data.

Our studies have demonstrated that recurrent pain in the joints is an initial symptom of impending exacerbation, which may be seen long before the onset of objective inflammation.

The effect of resort therapy on the immunobiologic reactivity and the predictive value of observed shifts have been ascertained by us in patients with specific infectious (brucellous) polyarthritis. Reactivity of patients with hyperergic states, detected by immunoassays and allergy tests at the beginning of therapy, was returned to normal and the test results improved with therapy. Vice versa, hypoergic or anergic responses increased with therapy.

Immunoassays repeated after resort therapy showed, apart from its stable efficacy, further improvement of the specific response to brucellosis or even its disappearance. On the contrary, persistence of the immune response and its intensification were indicative of an acute episode of inflammation which was subsequently confirmed clinically.

A prolonged follow-up of patients also showed that the dynamics of the immune response can be used to differentiate between an exacerbation of a specific joint infection which alters these responses and an intercurrent infection which fails to alter them.

A study in patients with inflammatory joint disease of gonorrhoeal origin has revealed that both immediate and long-term results of therapy are lower in older inflammatory disease. Scarring-commissural forms of inflammation, comprising a series of joint diseases treated at resorts, are often irreversible. This motivated us to carry out a study in patients with non-specific and specific infection-associated joint inflammation of short duration. A group of patients with non-specific infectious polyarthritis (112 persons) and a group of patients with locomotor brucellosis (146 persons) were treated with combined resort therapy (balneotherapy concomitant with antibiotics) during the first year of a disease when subacute inflammation began to subside (92 persons) or when relapses were observed (66 persons). The immediate and short-term results of therapy were relatively stable (Table 22).

Such observations suggest the necessity for prescribing resort

Table 22. Comparison of Immediate and Short-Term Results of Resort Therapy of Patients with Different Forms of Polyarthritis

Form of polyarthritis	Immediate results of therapy (%)				Short-term results of therapy (%)			
	Significant improvement	Improvement	No response	Deterioration	Significant improvement	Improvement	No response	Deterioration
Infectious non-specific	4.8	86.7	7.0	1.5	6.4	78.8	12.5	2.3
Brucellous (locomotor)	—	88.1	8.4	3.5	—	76.0	16.4	7.6

herapy in the early phases of joint inflammation and the revisior of accepted indications for resort therapy of patients with differen diseases of joints. Until recently, only patients with chronic join diseases were thought to be eligible for resort therapy. However clinical evidence obtained by us in recent years suggests that com bined resort therapy of patients with joint diseases is indicatec before the alleviation of subacute symptoms. The earlier the pa tients are sent to resorts, the higher the immediate and short-term therapeutic results.

It is interesting to clarify the stability of a therapeutic effect in patients with chronic rheumatoid polyarthritis not only after the first course of therapy but after sequential courses of resort treatment We have evaluated the clinical response of patients who were treatec at resorts 2, 3, and 4 times (Table 23). Naturally, patients witl severe joint disease were the ones sent for continual resort therapy the therapeutic results obtained in these patients are most represen tative in terms of efficacy. Thus, 38 per cent of patients with rheuma toid polyarthritis readmitted to the clinic after one course of therapy were known to have previous histories (before resort therapy) o peri-paraarthritis (90 per cent) and associated locomotor functiona disorders (35 per cent), abnormalities of other organs and system (toxic infectious myocardial dystrophy, hepatitis, gastritis, poly radiculoneuritis, adnexitis), panarthritis (85 per cent), subluxation (32 per cent), ankylosis (18 per cent).

After the first course of therapy, inflammation abated in patient with chronic infectious polyarthritis and even reversed in som of them. As a result, the locomotor and visceral functions wer improved, and neurotic reactions diminished. This increased th working capacity. The clinical signs of joint inflammation disap peared in over half of the patients after the 2nd, and especially 3r

Table 23. Alteration of Clinical Symptoms of Joint Disease in Different Periods of Therapy

Major symptoms of joint disease	Periods of therapy							
	1st year		2nd year		3rd year		4th year	
	No. of patients	%	No. of patients	%	No. of patients	%	No. of patients	%
Pain	180	100	130	95	90	65	60	70
Inflammatory oedema	162	90	97	75	50	55	27	45
Inflammatory infiltrates	136	70	68	52	36	40	12	20
Enlargement and shrinkage of the fibrous capsule	153	85	85	65	40	45	21	35
Deformity and stiffness	63	35	39	30	23	25	12	20
Subluxations	53	32	39	30	23	25	12	20
Ankylosis	32	18	22	17	15	17	11	18

and 4th, courses of resort therapy; a substantial improvement was noted in the working capacity and static and motor functions (80 per cent of patients), unless there was clinical and X-ray evidence of subluxation and ankylosis. Moreover, compensatory osteoarticular and neuromuscular mechanisms were significantly improved by the continual therapy in patients with stable abnormalities in the osteoarticular system.

We also discovered that relapses of brucellosis and infectious arthritis involving organs and systems and previously unaffected joints occurred after the 1st and even the 2nd course of therapy in 15 per cent of patients despite the significant alleviation of signs and symptoms of articular inflammation; they were not observed after the 3rd and 4th courses.

We know patients with brucellous or infectious non-specific joint disease which relapsed any time between 3, 5, and 8 years in the absence of resort therapy, resulting in temporary incapacitation or even disability. Continual resort therapy (3-4 times within a few years) of patients with chronic joint diseases, even clinically severe at the onset, may not only arrest their progression but improve the working capacity of the patients as much as to make them actually healthy.

Numerous studies on the long-term results of resort therapy suggest that repeated courses of treatment at sanatoria consolidate the effect of previous therapy of patients with joint diseases. A series of clinicophysiological studies indicate a stability of the functional improvement obtained by the first course of therapy; the severity

of the clinical picture of chronic joint diseases is usually reduced. Repeated courses of therapy often lead to a reversal of inflammation in the joints and recovery of the locomotor function in four-fifths of patients.

In conclusion, the evaluation of long-term results of resort therapy in patients with joint diseases testifies to the important role of resort factors among general therapeutic measures. The use of resort factors to treat these diseases has a beneficial effect on the course of inflammatory and degenerative processes in the joints, functional recovery of the adaptive systems, and the general condition and working capacity of patients. Continual resort therapy prevents relapses and exacerbations or progression of a chronic disease by facilitating a stable remission, sometimes resulting in recovery of patients. The physician-patient relationship plays a great role in it.

Chapter 17. The Physician-Patient Relationship

The problem of the physician-patient relationship has long been a part of medicine, obviously because of its principal importance in solving complicated diagnostic, therapeutic, and medicosocial problems.

Without dwelling on the historical aspects of this problem, we must emphasize that it has been viewed from different perspectives at different stages of medicine development. The views of medical men and sociologists on the role of this relationship in improving the patient's health have undergone more than one change. Naturally, the relationship involves the physician responsible for the patient's health, as one party, and the patient with the entire complexity of his/her nature, health anxieties and the physical and psychological strains caused by the disease, as the other.

The first issue is the way the physical and psychological strain arises and the essence of it. However difficult it may be, the issue undoubtedly has human and biomedical implications. An understanding of it will enable the patient to take efficient measures of primary and secondary prophylaxis and, hence, avoid numerous diseases or progression of the disease which is already present.

The onset of a disease is often associated with the strain of the neural processes in the cerebral cortex, especially as the stimulation process is predominant over the inhibition one.

I. P. Pavlov pointed out that a cortical collision of the stimulation and inhibition processes results in neurosis. The latter complicates any somatic disease and enhances susceptibility of the central nervous system to any environmental and internal stimulus.

Various functional, inflammatory and degenerative diseases induce functional disorders of the adaptive systems, affecting neurohumoral regulation and resulting in accumulation of metabolites; in turn, the metabolites affect the nervous system. By irritating the sensitive nerve endings, they increase pain sensitivity through complicated regulatory mechanisms, cause intoxication of the organism and psychological strain. The patient begins to consider the disease

as rendering him/her inferior in a society, since it impairs functional activity, working capacity and, therefore, financial security. However, sick-leave days are paid by the social insurance agencies in our country, and a period of temporary incapacitation is provided for; the patient is switched to invalidity as this period expires. Of course, pension pay renders the patient less well-off and every-day living more difficult. It affects the patient's morale and the course of a disease.

With an emotional injury, patients may be unwilling to communicate 'openly' with their physician. Nevertheless, the patient must give the physician a sequential story of what (s)he thinks to be the basis of a disease. Yet the story must not be allowed to drift, since the patient may thus distract the physician from critical determinants of a disease.

There must be an active physician-patient dialogue. It must be steered by the physician toward the clarification of aetiologic and pathogenetic factors, since causes reported by the patient may be irrelevant.

The physician must be able to arrange the relationship so that the patient does not hold back anything in his her story, even what may be intimate. This openness is required for detecting details important in the mechanism of a disease. The patient should trust the physician, a person committed by the Hippocratic oath to protect the patient's confidence. The physician is obligated not to discuss the information provided by the patient with his her relatives or friends, even if it is an important factor in a disease.

It is possible that a disease may be dangerous to other people. In this situation, the physician warns the patient of his her responsibilities, and takes medicoprophylactic measures against the occurrence of the disease in other persons. In any case the physician solves the issue by helping the patient and obeying the medical secrecy.

The physician-patient relationship must be based on mutual confidence. The physician must create an atmosphere which makes the patient feel that various facets of his her life are explored for an understanding of the origin and course of a disease, not for curiosity or other reasons.

For the sake of his/her health the patient must relate to the physician the events preceding the disease, and feelings and anxieties about this or, perhaps, other diseases the patient is unaware of. The physician must be able to encourage the patient to tell his her story and the perception of it, since an accurate subjective report may reflect objective character of a disease.

Results of objective patient examinations using updated clinical, electrophysiologic, biochemical and morphological tests in conjunction with anamnestic data enable the physician to infer the nature

of a disease, i.e. make a preliminary diagnosis. Conclusive diagnosis and therapeutic response are ascertained by observation of a patient.

Therefore, the physician-patient relationship must be frank and trustful; the patient must feel relief after the interview. V. M. Bekhterev correctly stated in the end of the last century: if the patient does not feel better after the physician's visit, the physician is bad. This remains to be true today, because the patient cannot have faith in the physician if the following questions go unanswered: what the disease that brought him/her to the physician is?; what is to be done next?; what life is to be like now?; and what effective therapy is being prescribed? Faith in the physician soars when the patient responds positively to prescribed remedies. It should also be borne in mind that a caring and kind attitude of the physician is no less helpful in therapy than drugs or other medical means.

We think that the patient must be treated with the patient's help. The physician must not be condescending to the patient: to solve the medicoprophylactic problems is to recruite the entire resources both of the physician and the patient. It is a shared concern.

It is required that the patient always has sympathy, the patient's mood is understood, and the physician's entire knowledge, experience and, if you will, talent are concentrated on relieving the patient's suffering, alleviating the severity of a disease, and rehabilitating the individual for work. The patient's health can be improved only as the emotional tone is raised, faith in recovery is instilled and, what is more, the physician is confided in and recovery is wanted by the patient.

American scientist, writer and public figure, Prof. Norman Cousins, wrote that he was always inclined to think that medicine would cure him, but then he understood that he must recruit his own resources. He decided that if he wanted to be the one-in-five-hundred, he didn't have right to be a bystander*. The attending physician of Cousins was told by a New York clinician that the recovery rate in ankylosing spondyloarthritis is 1 : 500, if it is recent, however.

Then what is the wanted recovery, recruited resources, not being a bystander? It means that, first, the patient must believe in recovery; second, must seek high emotions which can trigger mechanisms intensifying body chemistries; third, must raise the therapeutic potentials required for normal activity of the organism. The physician's word is of great importance in these processes. It is expected to create positive emotions, alleviate anxiety and instil confidence in recovery.

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* N. Cousins. *Anatomy of Disease: A Patient's View*. New York-London, 1979.

Obviously, to put activating positive emotions is quite a complicated task, yet it can be achieved by the physician-patient alliance. Professor Cousins said in his book that hope, love and faith helped his recovery. He even designed a system of being emotionally high which was primarily comedy films (fun therapy). It improved the course of his disease. The laugh relieved pain and gave 2 hours of quiet sleep. Upon waking he switched on the film projector, to have a few more hours of sleep. Reading humourous stories also had a beneficial effect on the chemical processes in the body by activating them. The patient was simultaneously given high doses of vitamin C. The ascorbic acid 'worked' as the laughing did.

The experience of Cousins made him conclude that the will to live is a physiologic factor of therapeutic value, not theoretical abstraction. The physician plays an important role in activating the patient's resources and the will to live. Cousins wrote that the main thing his doctor succeeded in doing in fighting his disease was to assure Cousins that he was a respected and equal partner in the battle. Only in a normal physician-patient relationship can the physician fully recruit the patient's entire spirit and body resources for fighting the disease.

Thus, the high purpose and the will to live are the bedrock of human existence. What is the culmination of the patient's purpose and will and what changes occur in the organism is, unfortunately, unanswered by the book of Cousins 'Anatomy of Disease'. However, thoughtful consideration of the complicated mechanisms accompanying this by the physician will make clear how emotions influence the human body.

A number of concepts might explain the system of improving the health and overcoming so severe a disease as ankylosing spondyloarthritis, suggested by the book discussed. In our opinion it should be the concept that positive emotions and the will to live give rise to conditioned reflex relationships between the brain cortex and the adaptive systems. The relationships are strengthened by humour, which is a source of high emotions stimulating the tone and reactivity of the cortex. It activates the sympathetic nervous system which promotes the release of chemical regulators of the anterior hypophysis. The latter intensifies the synthesis and humoral release of the adrenocorticotrophic and thyrotrophic hormones which activate the adrenocortical function and modify the thyroid function. In turn, the higher steroid hormone synthesis exerts anti-inflammatory and antidepressant effects (inhibition of collagen destruction) suppressing the immune inflammation underlying ankylosing spondyloarthritis. Furthermore, the functional stimulation of the thyroid alters the metabolism.

Regular exercise improved the physical fitness of patient Pablo Casals who was 90 years old and had rheumatoid arthritis. His daily

ritual was to go in the morning to the piano instead of the dinner-table. His fingers slowly extended, stretching out for the keys. His back became straighter. The fingers touched the keys. He was humming as he played Bach, and, as the piano died away, he would say that Bach spoke to what is here—his hand touching his heart. There was no trace of stiffness as he immersed himself in music.

No doubt, the high emotional and spiritual pitch, the striving for life strained on the adaptive systems; the emotional regulation and functi nal activation of the systems resulted in the abatement of inflammation, reversal of hypocorticoidism, locomotor improvement and better environmental adjustment.

The patient's longing for recovery has the effect no less intense than that produced by drugs, so the patient must believe in what is recommended by the physician.

Only the alliance of the physician and the patient can resolve numerous problems of primary and secondary prophylaxis of the onset and progression of commonly occurring functional, inflammatory, and degenerative diseases.

The physician plays a great role in dealing with these problems. The physician's priorities are to find out the nature and degree of the functional impairment of an adaptive system and to decide which physical prophylactic methods can restore or regulate the vital functions of the patient. This role is especially important in diagnostic and medicoprophylactic decision-making.

The patient is no less responsible for complying with the physician's recommendations on living and working regimen, avoidance of risk factors and harnessing his or her own forces and will in order to produce a favourable mental and emotional setting required for overcoming the disease.

In summary, it is quite obvious that reversal of a disease is a complicated task requiring a well-arranged physician-patient relationship.

Becoming Healthy

To be healthy is every human's desire, for everyone is aware of the neural deterioration or loss of health inherent in every disease. Therefore, the primary prophylaxis for the entire population of the country has immense medico-biologic implications. However, not all people seem to understand that healthy improvement prevents diseases and that prophylaxis is better than cure.

The currently available medical and social measures are directed towards ensuring favourable working and living conditions, improving the systemic resistance, abolishing local infections, promoting the tone and reactivity of the neuromuscular system, abolishing hypodynamia and risk of a disease. This is something that everyone must know, remember, and take care of.

If the disease does occur, there arise difficulties of diagnosis and use of medicoprophylactic measures to arrest its progression.

A patient may wonder why diagnosis-making and effective therapy are so complicated. Indeed, science has reached unprecedented heights: it is informed on the intricate conversions in the live cell; protein (material required for making up a cell) has been synthesized; the structure of enzymes and hormones, vital in any cell, has been elucidated. Moreover, processes of growth and development have been investigated in the human embryo, and genetic factors, crucial in hereditary diseases, have been discovered. The fantastic idea of fertilizing the ovum with spermatozoa and tracing the growth and development of the organism under artificial conditions has been implemented.

Yet the physician has difficulties in diagnosis-making despite scientific progress. Then what makes it so difficult to accurately diagnose a given disease? The reason is that, dear Reader, the diagnosis is a generic notion connoting alterations produced by the on-going struggle of the organism against harmful factors. The struggle occurs against the background of a 'break-down' of some functional system and the consequent appearance of adaptive and protective mechanisms. Moreover, the struggle occurs under newer functional and dynamic conditions during every temporal period. Therefore, a newer level of response of the vital control and maintenance systems of the body, or newer integrated response to various stimuli, is produced by the evolving disease. Not aetiologic but pathogenetic mechanisms are operating here, primarily auto-immune processes, metabolite storage, or abnormal reactivity.

Hence, a diagnosis must be made on the basis of dynamic observation of the course of a disease. The phase of a disease, activity of the inflammatory, or stage of the degenerative, process are important constituents of conclusive diagnosis and differentiated use of medical and preventive measures for a given patient. It should come as no surprise if no diagnosis is made by the physician after the initial examination of the patient. A thoughtful and experienced physician of versatile knowledge will always refrain from making a hasty diagnosis. Only a detailed consideration of the body changes observed during a follow-up exam enables us to comprehend the disease processes and accurately define the functional, inflammatory or degenerative disease. It may happen that an aetiologic factor is relegated to the background, having done its share. In a certain stage of a disease its role is slighted, since new, pathogenetic, mechanisms appear, making the disease progressive. It is appropriate to describe it as 'The Moor has done it, the Moor may quit'. It may happen, however, that the 'Moor' is hidden and its destructive effect continues; this warrants a change in the physician's approach.

Several examples will be presented. A patient has rheumocarditis.

The 'Moor' is a beta-haemolytic streptococcus of group A, located in the tonsils. It has been demonstrated by the prominent Soviet scientists, Monaenkov (experimentally) and Anokhin (clinically) that, although it had done its share—this local infection acted as a triggering mechanism of rheumocarditis—in exacerbations of it the infection may facilitate myocardial and endocardial inflammatory processes. Therefore, not only cardiac but tonsillar alterations must be considered as the pathogenetic therapy is planned. Exacerbations of this insidious disease may be prevented by control of the local infection.

Example two. A patient has biliary tract dyskinesia. Today physicians are able to diagnose and treat this disease, yet therapeutic measures must not be confined to the liver. Such a case requires regulation and restoration of functions of the central nervous system, otherwise disorders of the motor and evacuatory functions of the biliary tract and gallbladder will persist. Moreover, therapeutic success will be transient or the disease will recur unless a stable corticovisceral relationship is established, i.e. unless there is a normal relationship between the cerebral cortex and the biliary tract.

Example three. A patient has nephrolithiasis. The physician makes a diagnosis of it on the basis of clinical findings and special tests. Frequent renal colics with agonizing pain often compel the physician to recommend surgery. However, removal of the stone from the renal pelvis is not a radical measure, since the mechanism of this disease is more complicated than stone formation and pain attacks only. These symptoms indicate the disease. The important measures in the combined therapy of nephrolithiasis are modification of mineral and water metabolism, reversal of local kidney and pelvis abnormalities, correction of conditioned reflex relationships which are induced by different mechanisms and which result in nephrolithiasis attacks of various frequency and severity. Dietary therapy, mineral baths and mineral water intake are valuable procedures, but they must be prescribed only by the physician.

Therefore, the patient may become healthy only if an early diagnosis is made by the physician, the form and stage of the disease are accurately defined, and an optimal regimen of work and life is prescribed. It means that based on his/her experience, the physician has evaluated the general clinical essence of the disease, the nature and degree of impairment of the adaptive systems, and the functional dysregulation of each of the systems. This approach enables the planning of an adequate therapeutic and prophylactic regimen to be followed in defined sequences and periods for functional stabilization of each of the numerous adaptive systems. If the physician succeeds in these tasks, the patient's avoidance of the risk of recurrences and the longing for recovery, promoted by the physician

and relatives and active in the patient (as was the case with Prof. Cousins), will enable the patient to become actually healthy.

The dispensary control of patients and early secondary prophylaxis guarantee the success in improving the health of people.

Why should so high a priority be given to secondary prophylaxis? There are multiple diseases which become chronic and tend to relapse. The relapses may occur with no provocation, being characteristic of the disease. However, the relapses can be evoked by stress factors, leading to the advance of a disease.

What are the underlying mechanisms of relapses and are they preventable? The answer must be differentiated, for the mechanisms of relapses vary with diseases. Imagine a patient with rheumatoid arthritis which relapsed 8-10 months after a course of physical prophylactic therapy. How does the relapse occur in this case? The rheumatoid process is reversed because physical therapy increases the hypophyseal-adrenal function, mainly oxycorticosteroid synthesis, and alleviates hypocorticoidism. The steroid hormones make the cell membrane rigid, and exert an immunosuppressive effect, i.e. they inhibit collagen destruction and, consequently, reduce antigen formation. This prevents the deterioration of the immune inflammation. In malnutrition, especially deficiencies of vitamins and trace elements, the nutritional and energy resources required for normal functioning of the adaptive systems are reduced, hypocorticoidism recurs, and antigen production is enhanced, resulting in the relapse. The probability of the relapse is higher in local infection exacerbation, which, in turn, increases the systemic susceptibility. The disease is aggravated by adverse factors occurring against the background of a lowered resistance. Our studies of many years led us to conclude that such patients require continual application of physical methods of the secondary prophylaxis. These methods must be used in polyclinics, medical units, sanatoria or hospitals in 6-7 months following the first course of therapy. They prevent relapses by renewing body defences and correcting functional disorders.

Therefore, the prophylactic therapy (high- or ultra-high frequency electromagnetic waves, sulphide and radon baths, drug electrophoresis, medical exercises, massage) must be used before the relapse is manifest, not at the onset of hypocorticoidism, pain, or motor disorders. But the therapy requires an understanding of the complexity of the disease and compliance with the physician's advice. The patient must understand that regular prophylactic courses are by far more effective than mere treatment of an isolated rheumatoid attack. The attack involves not only joints but the heart, kidneys, liver, and other organs.

Other recovery-oriented prophylactic measures must be used in the presence of hypertension. A normal living and working regimen, avoidance of mental and emotional strains inherent in conflict situa-

tions, and periodic use of drugs and physical therapy are all crucial factors in the effective treatment of this disease. This regimen proves effective if employed on a differentiated basis, with regard for disease stage. Avoidance of mental and emotional strains resulting from domestic and occupational conflicts is a prerequisite of successful secondary prophylaxis at any stage. The patient with hypertension must avoid all strife. However, neurosis in these patients may make the patients incapable of self-control, entangling them in some or other conflict. Therefore, the members of the family and of the work team the patient belongs to must protect him/her from stress factors or conflict situations. Prophylactic mental therapy in the sanatorium, general health-improving measures (water rub-downs, showers, baths, back-neck massage), drug treatment of a 'breakdown' contributing to the disease, optimal sleep and rest regimen are priorities in managing these patients. Patients with hypertension must be dismissed from night-shift work. Patients with early-stage hypertension ought to use their vacations for resort treatment, and those with severe hypertension for treatment in the local sanatoria. Thoughtful adherence to secondary prophylaxis by hypertensive patients guarantees disease reversal and recovery.

Secondary prophylaxis must not be the same in different diseases. Moreover, there must not be a routine use of it in different patients with the same disease. The treatment must be individualized by the physician and complied with by the patient. We may speak of actual recovery only in these terms. We will emphasize: actual, for molecular and subcellular abnormalities are feasible after a disease is sustained. The after-processes in the nerve cells of the cerebral cortex may cause the disease to recur as adverse stimuli are present. A local anabiotic (latent) infection may likewise be triggered. A functional imbalance of the adaptive systems during an actual convalescence may cause an impairment in the hormonal processes, resulting in hypocorticoidism, hypoinsulinism, hypothyroidism. This may reactivate the pathological process, making an actually healthy person a patient.

These facts show the great difficulty of discriminating between the actual recovery and the possibility of disease relapses. The patient must be informed of these pitfalls so as to be able to use the physician's recommendations efficiently. These problems are the concern of both the physician and the patient, for they are allies in the fight of a disease.

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Subject Index

ACTH 73ff, 80, 126, 194, 231, 252, 256, 306f
aerotherapy 21, 50f, 101f, 151, 171
angina pectoris 129ff, 141f, 151, 161, 196f
ankylosing spondyloarthritis 59, 228, 299ff, 365f
articular mouse 339, 341
atherosclerosis 19, 39, 51, 67, 102, 124ff, 143, 147f, 161, 173, 224, 230, 243
autoimmunization 282

balneoreaction
  pathological 93, 141, 190, 251, 260, 281, 300, 309, 323
  physiological 93
balneotherapy 20, 46, 88ff, 142f, 151, 161, 166, 170, 179f, 189, 221, 224, 292, 300, 330f, 356f
baths
  air 22, 136, 156, 159, 171f, 190
  carbonate 59, 95ff, 138ff, 156
  iodobromine 97, 156, 171, 179, 251ff, 303ff
  radon 48, 64f, 96ff, 139ff, 166f, 171, 178f, 188, 205f, 213f, 220f, 257f, 300f, 337f 356f, 370
  sodium chloride 97f, 111, 156, 171, 188, 214, 300f
  sulphide 59, 63ff, 94ff, 138ff, 156f, 178f, 188f, 257f, 300f, 370
  sun 154, 190
brine
  strong 38
  ultrastrong 38

carbon dioxide 42, 46, 81ff, 108f, 135, 139f, 156, 159, 163, 193
chemical effect 100, 206
chronic venous insufficiency 181ff
climatotherapy 20, 51f, 88ff, 144f, 166, 170, 178, 188, 197, 226
coxitis
  tuberculous 330f, 334, 346
current
  direct electric 24, 134
  sinusoidal modulated 24, 69, 134, 161f, 178, 189, 205, 214

decimetre waves 20, 69, 78, 189, 204f, 213f, 251ff, 301f, 326f
deforming arthrosis 56, 59, 68, 104ff, 227ff, 329f, 334, 338, 344, 354
disease
  Addison's 73
  Köhler 337f
  König 339f
  Legg-Perthes-Calvé 330f
  Osgood-Schlatter 335f
dyshormonism 209
dyskinesia 57, 66, 194, 369

electromagnetic waves 63, 79, 134, 144, 204, 214, 300, 306f, 322, 326, 370
electrophoresis 24, 162f, 179, 370
electrotherapy 20f

fango therapy 226, 308, 330f, 357
four-cell baths 122, 136, 142, 180

gastritis 208, 291, 360

heliotherapy 21, 50f, 101f, 151ff, 171
hydrokinesitherapy 20, 139, 190f
hypersensitivity
  delayed 283f, 299
  immediate 283, 299
hypertensive disease 36, 39f, 48, 51, 56ff, 102, 120, 125ff, 142, 146ff, 260, 291, 370f
hypertonic crisis 135, 147, 150f, 164
hypnosis 172
hypocorticoidism
  syndrome of 63, 72f, 115f, 168, 286, 303f, 367, 370f
hypotensive disease 39, 142f, 146, 153ff, 167ff, 260
hypoxia 119ff, 139, 148f, 153, 161, 165, 174f, 179f, 186, 194
hormones
  steroid 74ff, 89, 107, 117, 211, 256, 285f, 300f, 370

inductothermy 20, 107, 300ff, 317ff
infectious hepatitis 216ff
intervertebral osteochondrosis 59, 68, 104, 111, 158, 177, 291
ion and gaseous composition
  formula of 49f, 90
ionophoresis 172
ischaemic heart disease 21, 39f, 56, 59, 104ff, 118ff, 155, 162f, 260, 29

macroelements 155, 178, 204, 210, 224
magnetotherapy 180
manoeuvre
  Valsalva 186
massage 143f, 180, 188f, 214, 251f, 256, 260, 302, 308f, 326, 337, 339f, 357, 370f
materials
  energy 71ff, 105ff, 114, 120, 128ff, 179, 188, 192, 209f, 215, 223, 239
  formative 71ff, 108, 114, 120, 128ff, 179, 188, 192, 209f, 215, 223, 239
menu 200ff, 212, 223
meteoneurosis
  disadaptation 51, 102
microelements 28, 31f, 34, 40f, 98, 155, 204, 210, 224
mineralization of water
  high 38, 90, 204
  low 37, 90, 204
  medium 38, 90
  weak 37, 90

mistakes
balneotherapeutic 343ff
diagnostic 343ff
mud therapy 28f, 37, 50f, 61f, 84ff, 177f, 188f, 197, 205, 214ff, 292, 300, 310ff, 321ff, 337ff, 356f
myocardial infarction 20, 118ff, 164f

obliterating
atherosclerosis 175, 178f
endarteritis 173, 177f
osteochondropathy 329ff
oxycorticosteroids 73ff, 115, 286, 301f, 311, 316, 370
oxygen tent 180, 224

paraffin packs 205f
pelotherapy 20
phlebothrombosis 183f, 189
phonophoresis 24, 152, 163
phototherapy 20
physiotherapy 151, 170, 193f, 218, 224, 228
plaques
atherosclerotic 19, 125, 130
postresection syndrome 198
prophylaxis 27, 49, 79, 83, 123, 130f, 149f, 164, 179, 189f, 196f, 218f, 301, 353, 363, 367, 370f
psychotherapy 170, 172

reactions
meteopathological 151
regimen 132, 144f, 151f, 194, 201, 209f, 309, 332, 367, 369f
rehabilitation 24f, 29, 118ff, 131ff, 143f, 189, 198, 208, 220, 225, 230, 281ff, 308
results
immediate 352ff
long-term 351ff
short-term 352ff
rheumatoid arthritis 20, 48, 56f, 72f, 78, 104ff, 168, 227f, 248, 281ff, 299ff, 344, 354, 367f
rheumatoid factor 281ff
rheumocarditis 61ff, 72f, 78, 104ff
risk factors 56f, 118, 124f, 146, 164

semibaths 136, 156, 190
speleotherapy 163f
stress
emotional 55f, 66, 73f, 102, 126f, 137, 146, 162, 281

systems
adaptive 18, 37, 46, 51f, 67, 72, 77ff, 97ff, 102ff, 104, 126, 132, 139ff, 151, 163, 168, 174, 188, 194f, 204ff, 235, 246ff, 285, 301ff, 362f, 370f
immunity 18, 113f, 188

temperature factor 48f
terrain cure 21, 110, 123, 144, 159, 172
test
Delbet-Perthes 182
Goldwasser-Chopard 298
Hackenbruch-Sequard 182
Kehr 216
Mayo-Pratt 182
Mussy 216
Ortner 216
Schick 286
Strelnikov 182
Trendelenburg 330
Zaharov 216
thalassotherapy 50, 101, 151
therapeutic effect 84ff, 134f, 141f, 152ff, 163f, 178f, 188f, 192ff, 205, 212, 218ff, 231, 251, 255, 281, 300f, 354f, 360
therapy
combined 19, 52, 101f, 117ff, 134, 155f, 170f, 177f, 188f, 197, 208, 214ff, 227ff, 299ff, 319, 346, 353, 356f
thermal effect 99, 206f, 300
thermoasymmetry 51, 102, 135, 186, 253f
thromboangiitis 176f
thrombophlebitis 183f, 189
trace elements 49, 63f, 100, 104ff, 125ff, 138, 155f, 188, 192, 204, 210ff, 240f, 251, 253f, 326f, 370
two-cell baths 122, 136, 142, 180

ulcer
duodenal 55f, 59, 66, 104ff, 152, 167, 193ff 291
gastric 55f, 59, 66, 75f, 104ff, 152, 167, 193ff, 291
ultrasonics 20, 69, 163
unit
Svedeberg 283

water
mineral 28ff, 64f, 84ff
thermal 28ff, 91, 97

zone
Zaharyin-Head 196, 214

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Discourse in level of Vector function. 5/1/82 Zhang

Printed in the Union of Soviet Socialist Republics